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THE RELATIONSHIP BETWEEN DECODING SPEED AND COMPREHENSION SKILL AMONG SKILLED AND LESS SKILLED CHINESE PRIMARY SCHOOL READERS

by

©

JOHN WING LING TSE

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND
RESEARCH IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR
THE DEGREEE OF MASTER OF EDUCATION

IN

SPECIAL EDUCATION

DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

EDMONTON, ALBERTA

SPRING 1987

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled The Relationship Between Decoding Speed and Comprehension Skill Among Skilled and Less Skilled Chinese Primary School Readers submitted by John Wing Ling TSE in partial fulfilment of the requirements for the degree of Master of Education in Special Education.

....P. Mulcahy......

Supervisor

....

....

Date. Dec. 3rd 1986

ABSTRACT

The notion of automaticity is important to the understanding of reading comprehension difficulty. LaBerge and Samuels (1974) put forward a model of automaticity in reading stating that the slow decoding speed on the part of the less skilled readers consumed excessive attentional resources, and as a consequence, comprehension suffered. The purpose of this thesis was to examine the relationship between decoding speed and comprehension in the Chinese language. Altogether 80 Chinese pupils from primary 2 and 4 classes were selected as subjects; a) by teachers on the basis of their reading achievement in class; b) according to their performance in Chinese Oral Reading Comprehension Test; and were further divided into skilled and less skilled reader groups. A discrete-trial procedure was used to measure decoding speed in terms of latency to stimuli on matching and vocalization tasks.

Results generally confirmed predictions. Skilled readers were faster on the naming and vocalization tasks than less skilled readers. Although the former were superior in naming simple Chinese characters (with few strokes) to the latter, the reaction time of the skilled readers in naming complex Chinese characters (with more strokes) was equivalent to the naming of simple char-

acters by the less skilled readers. A word frequency effect was apparent with high frequency characters and words responded to faster than low frequency characters and words. Older readers also responded faster than younger readers in high and low frequency Chinese characters and words indicating that an increase in decoding speed was also a function of development. Speed on a dot pattern matching task was found to be the significant predictor of reading comprehension ability among the less skilled readers, whereas the speed of vocalization of characters and naming of high frequency words were the reliable predictors of reading comprehension ability for skilled readers.

Research studies employing English speaking subjects have repeatedly demonstrated that skilled readers have faster decoding speed than less skilled readers. The present results not only revealed that such a relationship exists among Chinese readers, but also tended to support LaBerge and Samuels' (1974) model of automaticity in reading. The present findings indicated that less skilled readers perform relatively poorly on decoding tasks because of poor general retrieval and a coding deficit.

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CHAPTER I

INTRODUCTION

One of the main concerns of educators and psychologists is the wide range of reading ability among children of all ages. Skilled and less skilled readers differ in performance on a variety of general tasks (Downing & Leong, 1982; Golinkoff, 1976; Stanovich, 1982), but until recently little attempt has been made to explore how children of different levels of reading ability might differ in decoding processes. Generally, a child with reading difficulty may be poor in both speed of decoding and comprehension, good in decoding speed and poor in comprehension, or poor in decoding speed and good in comprehension. The third problem is the easiest to solve, while most reading specialists and psychologists tend to tackle the first problem. It is likely that poor readers may have faulty habits like excessive word analysis and slow decoding; as a result, comprehension suffers.

The problem of explaining the observed variance in reading comprehension skill in terms of the cognitive processes involved has attracted considerable attention. One possible explanation was offered by LaBerge and Samuels (1974). Using the limited capacity model of working memory, they postulated that the faster and more automatic is word processing, the more the space in memory is available for the execution of higher level processing such as comprehension. The relationship between decoding and comprehension is central to LaBerge and Samuels' model of automaticity in reading. Slow decoding would consume a lot of attentional resources, and since decoding and comprehension share the limited attention capacity, comprehension would be adversely affected. Smith (1975) also argued that less skilled readers often concentrate on decoding individual words and consequently do not try to construct the meaning of sentences. Paris and Meyers (1981) echoed that less skilled readers may adopt decoding rather than meaning comprehension goals during reading.

The relationship between the ability to decode words and reading comprehension is particularly strong in the early grades. The correlations between decoding speed and reading comprehension have been consistently in the range of .50 to .80 (Biemiller, 1977/78; Curtis, 1980; McCormick & Samuels, 1979; Perfetti and Hogaboam, 1975; Stanovich, 1981; Stanovich, Cunningham, & West, 1981). Of course, the observation of this correlation does not justify a causal inference. While skill at word decoding would somehow lead to increases in reading comprehension, it is possible that skilled readers are exposed to more text and as a result become more efficient in recognizing words. However, results from longitudinal studies (Biemiller, 1970; Lesgold & Resnick, 1982) do indicate that the relationship between decoding and comprehension is unlikely to be incidental. There is ample evidence documenting that skilled readers have faster decoding speed than less skilled readers (Biemiller, 1977/78; Curtis, 1980; Perfetti & Hogaboam, 1975).

Reading difficulties have been explained in terms of the relatively weak linguistic processing on the part of the less skilled readers (Gleitman & Rozin, 1977; Liberman & Shankweiler, 1979; Vellutino, 1979). In English, the symbols stand for units of sound--the phonemes. Thus the symbol-sound relationship is one of grapheme-phoneme correspondence which exists only in the alphabetic writing system. Although the English writing system is phonemically based, it is not a phonetic writing system in the sense that each symbol stands in one-to-one correspondence with a single sound element. When attempting to teach reading to children, it is obvious that the sound-symbol relationship in English is far from consistent. For every rule in phonics, there are many exceptions that often confuse the learner. Researchers (Morrison, 1981; Rozin, Poritsky and Sotsky, 1971; Snowling, 1980; Steinheiser & Guthrie, 1978) have long argued that children have difficulty in reading because they have not mastered the symbol-sound correspondences in English. Is the English writing system responsible for the reading difficulties? One thing is certain, the acquisition of reading is affected by the nature of the orthography of the language that the child is learning to read (~~Kyostio, 1980~~; Malmquist & Grundin, 1980; Oney & Goldman, 1984; Rozin & Gleitman, 1977).

In a widely cited research project, Rozin, Poritsky and Sotsky (1971) trained children with serious reading problems to read logographic script--Chinese. The result indicated that with only 2.5 to 5.5 hours of training poor readers were able to read Chinese characters and form sensible sentences. Such a finding was not only encouraging but it also invited others to ponder the question: If Johnny can't read, does that mean Johnny can't read in general or that Johnny can't read English alphabetic orthography in particular? It is not unreasonable to suggest that human information processing may differ because information is presented in different orthography (Gibson & Levin, 1975; Park & Arbuckle, 1977; Tzeng & Wang, 1983). However, the studies on reading, and word decoding and comprehension in particular, were restricted to a single language--English. Furthermore, there is a widespread belief that

Chinese orthography maps directly onto meaning, whereas in English orthography the relation of symbol to meaning is mediated through the sound system (Gleitman & Rozin, 1977; Lee, 1982; Liu, 1978; Rozin, Poritsky & Sotsky, 1971; Treiman, Baron, & Luk, 1981; Tzeng, Hung, & Wang, 1977). Because of their unique formation and special script-speech relation, Chinese characters present interesting and important contrasts to English words for researchers of reading problems.

Research in the study of the psycholinguistic processes of the Chinese language has been scarce. Hence, there is an urgent need to replicate, if not pioneer, research in the processing of reading materials particularly at the word level in the Chinese language. While there is overwhelming evidence documenting the finding that with English-speaking subjects skilled readers have faster name decoding skills than less skilled readers, apparently, slow decoders tend to be poor comprehenders. It is certainly worthwhile to examine whether such a relationship exists when the stimuli are Chinese instead of English. The present author is interested in looking into the problem of reading difficulties and in particular the relationship between the speed of decoding and comprehension among skilled and less skilled Chinese primary pupils. In this thesis, the notion of decoding is defined as the vocalization or identification of graphic marks and comprehension is defined as reading for inferences, and drawing logical conclusions (Downing & Leong, 1982). The major research questions posed in the present study are as follows:

1. Would skilled readers have faster decoding speed than less skilled readers in Chinese character recognition tasks?
2. Do readers require more time to process complex Chinese characters and words than simple characters and words?
3. Would younger and less skilled readers take longer to decode low frequency than high frequency characters and words?
4. Does decoding speed make an independent contribution to the prediction of reading comprehension ability?
5. Would the relationship of decoding speed and reading comprehension ability change as readers develop?

In this thesis, the author also intends to examine the concept of automaticity in reading, and research especially relating to skilled and less skilled readers in decoding will be reviewed. To clarify misconceptions about the Chinese language, a chapter will also be devoted to addressing the psycholinguistic issues of the Chinese language. Hopefully, this research will give more insight into the information processing of Chinese and will shed light on the development of strategies in helping Chinese children with reading difficulties.

CHAPTER II

DECODING AND COMPREHENSION ABILITIES AMONG SKILLED AND LESS SKILLED READERS

Reading has been a focus of study from the information processing perspective which assumes that any cognitive task can be divided into stages and proceed in a fixed order over time (Gough, 1972; LaBerge & Samuels, 1974; Mackworth, 1972; Massaro & Taylor, 1980; Sternberg & Wagner, 1982). Given the information processing model, an important issue is determining the stage or stages of processing responsible for failure in reading comprehension. Repeatedly, researchers (Curtis, 1980; LaBerge & Samuels, 1974; Lesgold & Resnick, 1982; Perfetti & Hogaboam, 1975; Sternberg & Wagner, 1982) had argued that because of the failure to achieve automaticity in word processing, as indicated by slowness in decoding words, less skilled readers tend to experience difficulties in understanding the passages. With this perspective in mind, the purpose of this chapter is to examine the concept of automaticity and to review some of the research on the relationship between decoding speed and oral reading comprehension especially among skilled and less skilled readers.

AUTOMATICITY

Crucial to LaBerge and Samuels' (1974) information processing model is the role of attention. In the performance of new tasks, execution of information processing components is largely under the conscious control of the individual. Controlled execution of these components requires large amounts of attentional resources, which are then temporarily unavailable for other purposes. Eventually controlled processing is replaced by automatic processing. A sub-system of skills used to execute the tasks is then moved from controlled central processing to local peripheral processing. It is essentially stored into a new area of the information processor. When the sub-system is 'established', execution within it becomes automatic. The same attentional resources that were required for execution of a single information processing component in the central processor can now operate in the whole information processor sub-system. The resources formerly consumed by the sub-system can now be diverted elsewhere. For instance, the driving of a car initially consumes all the driver's attention, but later driving consumes only a small fraction of the driver's attention and can be accomplished simultaneously with other tasks. One can attend to the road, read a billboard, or chat with friends while driving. In other words, driving becomes automatic.

Reading a passage is another example of automatic processing. In the beginning, when a child is learning to read, reading is laborious and slow, and may proceed on a letter-by-letter basis. After years of practice, for an adult fluent reader, reading requires little effort. During fluent reading, the decoding aspects of the reading process are handled by an 'automatic mechanism', leaving the mind free to give more attention to the meaning.

LaBerge (1981), attempting to define the concept of automaticity, stated: "Automaticity (is) processing that......is unavoidable, without capacity limitations, without awareness, without intention, with high efficiency, and with resistance to modification" (p. 173). However, there is still no completely satisfactory definition of automaticity. The following characteristics may be incorporated as the sufficient conditions for the presence of automaticity (LaBerge & Samuels, 1974; Posner & Snyder, 1975; Shiffrin & Schneider, 1977).

Automatic processes do not:

1. require attention.
2. interfere with other processing.
3. necessarily give rise to awareness.

4. on their own lead to the storage of new information.
5. reduce capacity.

Automatic processes would:

6. be difficult to suppress once aroused.
7. run to completion once activated.
8. develop if given a large amount of practice.

LaBerge and Samuels (1974) applied the notion of automaticity to analyse the reading processes. Their model of reading assumes that a person's capacity of attention is limited (Norman & Bobrow, 1975). A person can attend to many tasks at a time if only one of these tasks requires attention. This indicates that some tasks can be performed automatically. A task or behavior is considered automatic when it can be performed while attention is on another task. The model explains that if the skill of decoding operated at an automatic level, not making excessive demands on attention, then attention could be directed toward better comprehension. If attention is focused on or diverted by decoding demands, it is difficult for comprehension to occur. In other words, when decoding is slow, higher level comprehension processes become resource limited. Performance is thus restricted by the amount of attention available.

According to LaBerge and Samuels (1974), reading can be considered as a two-stage process involving decoding and comprehension. A beginning reader has to strike a balance between attending to decoding and comprehension. Excessive attention on decoding would impede comprehension. A beginning reader has to switch attention back and forth from decoding to comprehension. As a consequence, reading is slow and laborious. However, as one masters the skill of decoding to the point of automaticity, one can concentrate on comprehension.

Central to LaBerge and Samuels' notion of automaticity in reading is the conceptualization: Fast decoding aids comprehension. During reading, comprehension involves sharing some limited capacity system among various task components. This same limited capacity processor has to be used to remember words already read and to think about the meaning of what is read. Hence, as decoding become faster, the resource required to monitor and maintain decoding decreases--allowing more effort to be directed toward understanding what is being read. In short, the lesser the work required by decoding, the more available the system is for the purpose of reading--comprehension. An interesting case is in reading poor hand writing, one often devotes so much attention to deciphering that comprehension suffers drastically. The acquisition of automaticity is related to the relaxation of control. In reading, the relaxation of control of lower-level processing is usually accompanied by a transfer of attention to a high-level. In skilled reading attention can be switched between levels. The notion of automaticity in reading and the well-known levels of processing approach to memory (Craik & Tulving, 1975) have at least one thing in common: that is, both models put much emphasis on the role of attention. In fact, as suggested by Craik and Tulving, when attention is directed to the manipulation of the level, from an analysis of physical features to extraction of meaning, it can affect the ability to recall materials. This durability of memory traces is a function of "depth of processing", where greater depth implies a greater degree of semantic analysis.

DECODING AND COMPREHENSION

Difficulty in word decoding may affect the reading comprehension process:

1. the search for the meaning of individual words would be disrupted.
2. the extraction of the relations specified between words would be hampered by a more indirect process, e.g. the overloading of short term memory (Golinkoff, 1976).

It appears that the relationship between decoding speed and reading comprehension skill is a forceful demonstration of the interaction among various processings of reading. Reading can be seen as an interactive process involving both "bottom-up" and "top-down" approaches according to learner abilities and tasks difficulty. The bottom-up approach refers to the processing that starts with the raw input and passes through increasingly refined analysis until the meaning of the text is eventually determined. In other words, the processing starts at the more peripheral levels and proceeds to more sophisticated levels in the system. The top-down approach refers to the processing when decisions made at the higher levels in the processing system are used to guide choices at lower levels. Thus, in reading when the reader analyses the text he has to draw upon his knowledge of the world and his knowledge of the structure of the sentences (Mitchell, 1982). Nonetheless, in fluent reading there is a switching back and forth from symbols to meaning and from meaning to the more analytic operation of identification of different units of processing--words, syllables, letters or features (Downing & Leong, 1982). For skilled readers the reading process is like an integrative one in the sense that they have mastered various subskills to automaticity. They have also mastered the component processing to automaticity and can deal rapidly and easily with the subskills. Less skilled readers tend to pay more attention to individual subskills such as decoding and consequently lose track of or cannot cope with the main purpose of reading--comprehension.

Perfetti and Lesgold (1979) used the analogy of a high fidelity (hi-fi) system to demonstrate the component processes involved in reading skill. If any component of the hi-fi system is defective, the quality of sound would be affected. The components can be independently tested and independently improved. However, improvement of one component may not immediately improve sound quality. Nonetheless, it may increase the potential of the system to benefit from subsequent improvement in other components. For instance, an improved cartridge will improve the sound quality only if the other components are capable of handling the input. Likewise, one might improve the speakers by widening the range of frequencies, but this will improve the sound quality only within the limits of the cartridge. The situation in both reading and hi-fi is similar in the sense that the degree of success at one level of processing is a function of the individual's skill of processing at other levels.

The relationship between comprehension and decoding is essentially an inter-dependent one. When decoding speed is slow, higher level processing such as comprehension becomes resource limited (Norman & Bobrow, 1975). Performance is dictated by the amount of attentional resources available. It seems fair to argue that decoding is necessary but not sufficient for comprehension. This is particularly true when reading comprehension processes are assumed to share working memory resources with decoding processes. A processing bottleneck is created when one reaches the capacity of the working memory.

Suffice it to quote a classroom teacher's (Stevenson, 1974) observation on the relation between decoding skill and reading comprehension performance. She stated:

> (T)here has been great emphasis put on developing the child's comprehension ability. It is true that poor readers in the upper grades wrestle with comprehension problems. I have found this problem stems mainly from the student's lack of word-decoding skill. The comprehension cannot improve until the reading process becomes automatic, a development that takes place after the conscious analysis skills have been mastered. Therefore, though you want the child to understand the story he is learning to read, his ability will not be perfected until the child actually learns to read accurately (p. 20).

In order to further examine the notion of automaticity, a review in the "rapid naming" research is much needed. The results of the rapid naming studies have usually been interpreted as confirmation of a general retrieval deficit in poor readers. Spring and Capps (1974), in an attempt to investigate the naming speed of dyslexic subjects found thay they named numbers, colors, and pictures more slowly than non-dyslexic subjects and that their responses to naming numbers were exceptionally slow. Denckla and Rudel (1976) also noted that the dyslexic children when compared with non-dyslexic-learning disabled children and normal children had significiantly longer latency in naming objects, colors, numbers and letters. While Ceci (1982), in a study to measure decoding speed among learning disabled and non-disabled children, also concluded that learning disabled children were significantly slower in responding to letter string pairs than non-disabled children. Seymour and Porpodas (1980), however, found that although the dyslexic subjects had a severe deficit in word naming, they named pictures of objects as fast as non-dyslexic subjects. Such conflicting findings were the results of studies using different criteria for subject selection and different modes of presentation of stimuli.

Research studies in decoding were by no means confined to the dyslexic population only. Golinkoff (1976) employed poor comprehenders (who were 1.5-2 grades behind reading level) and found that they had difficulty decoding unfamiliar words. Furthermore, their speed in decoding familiar words was slower than for good comprehenders. Golinkoff and Rosinski (1976) also found that poor comprehenders possessed weak decoding skills. Third and fifth graders read through 2 word lists. One contained nonsense words and one contained common list level words. When the time required by the good and poor comprehenders to read each of these lists was compared, it was found that good and poor comprehenders did not differ on the time to decode common first grade level words. However, the poor comprehenders took almost twice as long as the good comprehenders to decode the nonsense words.

Although the general findings seem to show that learning disabled children and poor comprehenders have slow word naming speed, the continuous naming procedure as employed in the above research tends to undermine a valid interpretation of the results. In a continuous naming paradigm subjects are asked to name visual stimuli in a series of rows or columns--all items are visible simultaneously. One problem is that subjects were timed on lists of items rather than individual items. Because errors were frequent especially among younger subjects and more so among nonsense-syllable lists than word lists, latency measures were contaminated by inaccuracies. As Stanovich (1981) noted the complex articulatory, scanning, and sequential-response processes that subjects employed may also influence the results of the continuous naming procedure.

The relationship between decoding and comprehension was examined by Perfetti and Hogaboam (1975). A discrete-trial procedure was used and subjects were asked to name rapidly items presented one at a time. Perfetti and Hogaboam measured how much time it took skilled comprehenders in the third and fifth grades to orally decode words presented in print. The findings suggested that skilled comprehenders pronounced words more rapidly than less skilled comprehenders. In the word naming tasks, words were classified in highly familiar, less familiar and pseudoword groups. While less skilled comprehenders pronounced highly familiar words more rapidly than less familiar words and pseudowords, skilled comprehenders pronounced all types of words rapidly. Perfetti and Hogaboam interpreted the results in terms of the notion of automaticity. The rapid pronunication of all types of words by the skilled comprehenders would imply that little attention was required to complete the tasks. Since skilled comprehenders were able to orally decode words faster than less skilled comprehenders could, they might decode automatically in a reading situation. Subjects who were classified as less skilled comprehenders were also slow decoders on all but highly familiar words. It was deemed likely that when these subjects were reading text, decoding might be requiring excessive amounts of attention for comprehension. Marr and Kamil (1981) replicated the same research and reached similar findings.

In another study to investigate the decoding speed between skilled and less skilled children, Perfetti, Finger and Hogaboam (1978) found no difference between the two groups on rapid naming of pictures, colors and numbers. However, significant differences were found on words with the latter group being slower. Samuels, Begy and Chen (1975-76) found that both skilled and less skilled readers were equal in their accuracy of word recognition but skilled readers were able to process the visually presented words faster. Stanovich (1981) measured the speed with which skilled and less skilled first grade readers named colors, pictures, numbers, letters and words. The findings indicated that skilled readers were more rapid in naming words only. This is consistent with the results of Perfetti and Hogaboam (1975). The fact that the naming times for colors, pictures and numbers for both groups were the same tends to suggest that a general name retrieval deficit does not seem to be a characteristic of less skilled readers.

In fact, the marked word naming difference together with the lack of a letter naming difference between skilled and less skilled readers supports the conceptualization that the deficit of the less-skilled readers is not in general visual processing skills but in phonological skills. This interpretation is further supported by an experiment by Katz and Wicklund (1971) who demonstrated that good and poor readers have the equivalent scanning rates for reading materials.

An important point to note in LaBerge and Samuels' (1974) model of automaticity in reading is that even if less-skilled readers can sound out most of the words they encounter, they do so very slowly. These children are likely to experience difficulty in reading and understanding a passage. When they direct their attention to the components of words rather than to the word as a whole, they tend to slow down drastically when what they need to do is to speed up. Because of the overattention on accuracy in recognizing word components, the efficiency of recognition of words and the making of meaning out of the text suffer (Lesgold & Resnick, 1982). It seems that accurate word recognition is necessary but not sufficient for advancement to the higher level skill--comprehension.

An interesting outcome was noted in Perfetti and

Hogaboam (1975) study that less skilled readers decode highly familiar words faster than less familiar words and pseudowords. This result confirms the earlier findings of Ruberstein, Garfield and Millikan (1970) who demonstrated that commonly occurring words are responded to faster than infrequently occurring words. The role of word frequency was also stressed in Morton's (1969) logogen model and Becker's (1979) verification model of word recognition.

The Morton logogen model (1969) assumes that there is a logogen (from logos meaning word and genus meaning birth) corresponding to each of the words in our vocabularies. The logogen helps to integrate information from sources pertinent to the recognition of a word. Whenever information is detected, the logogen is activated; when this activation reaches a certain thresholds, the logogen fires and the word is recognized. To explain the word-frequency effect, Morton asserted that high frequency words are recognized faster than low frequency words because the recognition thresholds of the high frequency words are reached faster than those of the low frequency words.

In the verification model of word recognition, Becker (1979) assumed that words are listed or ordered according to word frequency in the processing system and that the verification process works through the candidates one by one. Thus, a high frequency word at the 'top' of the list will be processed sooner than a word near the 'bottom' of the list and the result would be that the overall response latency would show a word frequency effect.

In Morton's (1969) as well as Becker's (1979) model major emphasis has been placed on the role of word frequency in activiating semantic memory. The basic proposition in these models is that high frequency words are recognized more rapidly than low frequency words. Word frequency can be considered as the number of times a word appears in a body of reading material. However, for an individual, it is not just how many times the word has been seen, but the situations in which it is seen that will determine the magnitude of frequency effect (Samuels, 1983).

DEVELOPMENTAL ASPECTS OF DECODING SPEED

The attainment of word recognition skills has been analyzed into three phases (Ehri & Wilce, 1983); LaBerge & Samuels, 1974). In phase 1, children identify unfamiliar words by directing their attention to component letters and letter-sound relations. At this stage, the focus is on accuracy of recognition. In phase 2, as a result of practice in reading, familiar words come to be recognized rapidly and automatically, that is, without deliberately attending to and processing subword components such as letters. In phase 3, the speed of processing familiar words increases to a maximum driven by the individual's general speed of information processing; at the same time various components of word recognition (e.g. letter identification, letter-sound mapping) become consolidated.

A study conducted by Curtis (1980) examines both the relationship between decoding and comprehension and changes in the importance of decoding speed over the period of reading acquisition. She pointed out that skilled readers were faster than less skilled readers and verbal decoding speed was correlated with comprehension skill. The speed of processing printed material significantly increased at successive grade levels. However, there was also a decrease in the amount of variance in reading ability explained by the reading speed measures. Thus, at initial stages of reading acquisition, regularity of grapheme-phoneme correspondences exerts a greater effect on comprehension than during later stages. As readers advance in reading skill, according to Curtis, they would be expected to develop automaticity in word recognition, which in turn would decrease the contribution of decoding to reading skill.

The developmental aspect of decoding ability was also examined by Biemiller (1977/78) who demonstrated that younger and less skilled elementary school children took more time to read letters plus words in and out of context than did older and more skilled children and adults. The former group also required more time to read words out of context than they did to read letters, while the latter group required the same time to read letters or words out of context. The development of word identification speed was studied by Ehri and Wilce (1983) who required skilled and less skilled readers in first, second and fourth grades to identify familiar printed words, consonant-vowel-consonant (CVC) nonwords, digits and pictures. Readers are inferred to have attained phase 3--the maximum word recognition speed--if they identified familiar words as rapidly as digits. Results indicated that skilled readers in all grades were able to identify words as rapidly as digits; but this was only accomplished by less skilled readers in fourth grade. Second and fourth grade skilled readers were also able to name CVCs as rapidly as they named digits, but not so less skilled readers at any grade. These findings suggested that there are significant developmental and skill differences between skilled and less skilled readers in terms of decoding ability.

In an experiment of the developmental aspect of decoding ability, McCormick and Samuels (1979) studied the decoding speed of younger and older readers' response to words varying in length between 2 to 7 letters. The assumption was that if readers are responding to words holistically as single units rather than componentially as a sequency of letters, then longer words should not increase reaction time. Results demonstrated that less skilled readers took longer to process each unit within the word, indicating that they process words in smaller units, whilst older and better readers processed increasingly longer words holistically. Juola, Schadler, Chabot and McCaughey (1978) employed kindergarten, second and fourth grade children as well as college students as subjects. A search task was used and subjects were requested to respond to a target letter followed by a three-, four-, or five-letter display. The findings revealed that reaction times decreased with age, and that response times increased linearly with the number of displayed letters, while responses were faster for word and pseudoword displays than for nonwords.

A similar research project was carried out by Samuels, LaBerge and Bremer (1978) who employed subjects from second, fourth, sixth and college levels to compare their responses in a categorization task in which the stimuli were words of varying lengths. Samuels et al. also reasoned that if readers are responding to words holistically as single units rather than componentially as sequences of letters, then longer words should not increase reaction times. Results revealed that word length effects decreased considerably between second and sixth grade. Subjects at the college level required the same amount of time to process the stimuli regardless of word length. Samuels et al. argued that the children were processing the words holistically as a single unit. It is important to note the difference in word recognition speed was related to the size of the perceptual unit used to identify words. Santa (1976/77) demonstrated that skilled second grade readers were able to match targets to words equally rapidly when the targets consisted of a single letter or the first two letters of the word, whilst less skilled readers were significantly slower at matching two-letter targets, relative to single-letter targets. Santa argued that the skilled readers were using larger perceptual units than the less skilled readers.

The findings of McCormick and Samuels (1979), Juola et al. (1978) and Samuels et al. (1978) tend to indicate the developmental aspect of cognitive ability relating to word processing; younger and less-skilled readers take longer to process longer words while older and skilled readers require about the same amount of time to process short and longer words. This word length effect on reaction time indicating steep slopes reconfirms results of other matching studies (Bruder, 1978; Eichelman, 1970) and lexical decision research (Butler, 1979). A somewhat related research project, carried out by Eriksen, Pollack and Montogues (1970), demonstrated that the number of syllables in a word is significantly related to the reaction time for overt vocalization.

POOR DECODING SKILLS

Studies on context effects on word recognition in children have consistently found that when the reading materials are within the difficult range, less skilled readers showed contextual effects on word recognition just as large as those displayed by the skilled readers (Biemiller, 1977/78; Perfetti, Goldman, & Hogaboam, 1979). In a study to examine the relation between reading acquisition and word decoding with and without context, Stanovich, Cunningham, and Feeman (1984) required skilled and less skilled first graders to perform in word recognition tasks. Skilled readers were better than less skilled readers in the word recognition performance on the coherent paragraphs; the former were also better at reading random word lists. Such findings indicated that the less skilled readers were getting as much contextual facilitation from the coherent paragraph as were the skilled readers when the latter were at a similar level of context-free decoding ability. Stanovich et al. (1984) suggested that less skilled readers were able to use context to aid word recognition, but were unable to use text-cues to facilitate comprehension. There is also ample evidence showing that less skilled readers are less adept at using contextual cues at the level of text integration and comprehension (DiVesta, Hayward, & Orlando, 1979; Paris & Myers, 19811; Smiley, Oakley, Worthen, Campione, & Brown, 1977).

There is some indirect evidence indicating the poor decoding of less-skilled readers. Biemiller (1970) studied longitudinally the oral reading errors of a group of first grade pupils and found that the majority of the subjects' reading errors consisted of a substitution of the correct word with an alternative that was semantically and syntactically acceptable within the sentence. However, the proportion of substitutions that were graphemically similar to the correct word increased toward the end of the year. Apparently, beginning readers find it easier to guess at the identity of an unfamiliar word than to decode it. Kolers (1975) also showed that the use of top-down processing to avoid decoding may be a fairly common source of reading difficulty among older children. In his study, skilled and less skilled readers between the ages of 10 and 14 years were presented with sentences in normal and reversed print. When the sentences were read aloud, the substitution errors of both groups were in general grammatically appropriate. But the less skilled readers made almost 10 times as many substitution errors as the skilled readers. In addition, the less skilled readers were relatively insensitive to graphemic aspects of the stimuli. Whilst the number of letters in the substitution responses of the skilled readers was highly correlated with the number in the printed word, this was not the case for less skilled readers. Poor reading was coupled with frequent guessing and relatively little attention to the graphemic aspects of the stimuli. This strategy seems to work quite well for simple beginning texts; however, there is little incentive for development of decoding skills. When the child is advanced to more complex material, decoding skills must be well developed because guessing will not suffice. Top-down processing clearly changes from a help to a hindrance when it is used to avoid decoding altogether.

This tendency on the part of less skilled readers in reading was explored by Stanovich (1980) who argued that because of their weak decoding skills, less skilled readers compensate by relying more on context cues to recognize words. Because of this alternate way to identify words, less skilled readers pay less attention to letters in the spellings of unfamiliar words seen in the text, and it takes longer for complete representation of specific words to be built up in memory. If new printed words are not learned completely, then general knowledge of spelling patterns and rules will not develop and facilitate further word memory processes. Readers generally can cope with visually unfamiliar words through either top-down or bottom-up processes. Although both types of strategies are important, neither is sufficient by itself. For the skilled reader, top-down and bottom-up approaches operate as complements to rather than substitutes for one another. Nonetheless, this can only happen when the processes involved in word recognition have been sufficiently overlearned or, in LaBerge and Samuels' term, automatic that they require minimal effort.

PRACTICE EFFECTS ON AUTOMATICITY

In an attempt to study the effects of practice on automaticity, Spelke, Hirst and Neisser (1976) carried out a study of writing while reading. At the beginning of the experiment, the reading speed and comprehension of the two subjects suffered seriously. But after 6 weeks, the subjects were able to attain the same levels as when they read without writing. It appeared that the subjects began to write automatically. The semantic relation among the dictated words was not detected at first. In order to encourage attention to these relations, the subjects were asked to determine whether successive words belonged to the same category or formed a sentence. With practice, they began to develop the ability to classify the words into semantic categories during dictation. This demonstrated that the subjects had understood the meaning of each dictated word while reading. Such results indicated that the subjects did not really perform both tasks at once, but attended to them in rapid alternation. In other words, they might have learned to 'time share' their capacity. Spelke et al.'s findings can also be interpreted as indicating that not all tasks must draw on central processing capacity. Simple activities may be performed automatically. It is possible that the subjects might have bypassed their central mechanisms and copied the dictated words without attending to them.

In an attempt to examine the assumption that an individual could not perform two comprehension tasks

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simultaneously without adversely affecting the performance of one or both tasks, Hirst and Spelke (1980) trained two subjects to copy dictated sentences while reading. After considerable practice, the two subjects reached matching performance criteria of copying errors, reading speed and comprehension when the tasks were done singly and together. In short, skilled activities became automatic. Hirst and Spelke asserted that the ability to divide attention is not dependent on resource considerations but rather on the level of skill achieved by an individual. This elimination of attention is consistent with the notion of automaticity, which applies when there is freedom from capacity limitations.

Ehri and Wilce (1983) also trained younger and less skilled readers to practise reading familiar words and consonant-vowel-consonant (CVC) nonwords. The findings demonstrated the speed of processing improved but still remained slower than digit naming speed which in turn indicated that practice promotes the development of decoding speed very slowly in less skilled readers. Manis (1985) required less skilled and skilled fifth and sixth grade readers to learn the meaning and pronunciation of unfamiliar words varying in word length and in letter-sound regularity and complexity. Results suggested that even after 10 exposures to practise, less skilled readers were slower to name the unfamiliar words than skilled readers. Furthermore, the reaction times of the less skilled readers were also significantly slower in a delay word naming task indicating that the differences in naming speed were due to inefficient decoding skills more than to the response of executive processes.

In another study, Hogaboam and Perfetti (1978) provided third and fourth grade skilled and less skilled readers with varying amounts of practice pronouncing pseudowords. They found that practice increased speed in both groups. However, skilled readers needed only 3 exposures to boost speeds for verbalizing pseudowords to being as fast as for high frequency words. In contrast, less skilled readers required 6 exposures to reach a maximum speed. Furthermore, comparisons of the maximum speed of skilled and less skilled readers showed that the latter group was substantially slower (i.e. about 1 second vs. 2 seconds per word) and this difference remained constant even after 18 exposures to the pseudowords. Such findings indicated that less skilled readers required more time to attain the maximum speed.

Generally, research (Hirst and Spelke, 1980; Spelke et al., 1976) on the practice effect on subjects with average reading ability has shown that automaticity is a learned process occurring after extensive practice. Findings of Ehri and Wilces' (1983) and Hogaboam and

Perfettis' (1978) research suggested that even though decoding can be increased with practice, the practice effect is not enough to compensate for the "slowness" of the less skilled readers in lexical decision naming tasks. The gain in decoding speed in isolated word naming tasks does not generalize and facilitate a higher level of processing such as comprehension.

STROOP INTERFERENCE EFFECT

Another experimental technique that has been used as an index of automatic processing is the Stroop task (Stroop, 1935). In the Stroop task, subjects are asked to name the color of the ink in which a word is printed. When the word indicated the name of a conflicting word (e.g. the word "black" written in red ink) color-naming is much slower than when the word is a nonverbal stimlus. This color-word interference effect can be explained in terms of the competition between vocal responses to the printed word and the ink color. Since the subjects engaged in a Stroop task are required to attend only to the color of the ink, color-word interference is interpreted as the result of the word having been read automatically.

In a study to examine the development of automatic word recognition skills, West and Stanovich (1979) required kindergarteners, first graders and third graders to perform a discrete-trial Stroop task. Subjects were requested to name letters, high frequency and low frequency words. The findings indicated that kindergarteners named color significantly slower when the target was a letter rather than a word; while first and third graders' color-naming latencies were not affected by the stimulus type. West and Stanovich explained the findings in terms of the notion of automaticity: the first and third grade children had automated the recognition of all the stimuli including the low frequency words. On the contrary, kindergarteners had fully automated the recognition of only the letter.

Stanovich, Cunningham and West (1981), in a similar study, required first graders to perform a Stroop task in which they named the colors of stimuli that were either letters, high frequency, or low frequency words. The results indicated that interference caused by letters exceeded that caused by high frequency words and the latter also exceeded that caused by low frequency words. As suggested by the notion of automaticity, better readers tended to display more interference and skilled first graders processed words more automatically than less skilled readers. Such findings are consistent with the results of studies in decoding abilities of less skilled readers (Curtis, 1981; Perfetti & Hogaboam, 1975).

Several studies have employed a picture-word analogue of the Stroop task to examine the development of automatic word processing in children (Ehri, 1977; Golinkoff & Rosinski, 1976; Guttentag & Haith, 1978; Rosinski, 1977). These studies required subjects to name pictures of common objects while ignoring words printed inside the picture. If subjects could not ignore the irrelevant words, their word processing was considered to be automatic. Thus, automaticity was inferred from the amount of interference the words produced with the task of naming pictures.

Experiments by Ehri (1977) and Rosinski (1977) indicated that familiar words could be recognized automatically be normal readers at the end of first grade and by less skilled readers at third grade. Guttentag and Haith (1978) also required early and late first graders, third grade skilled and less skilled readers and adults to name pictures under interference conditions. A word-interference effect was found for all groups except the early first grade children. Only third-grade skilled readers and adults were affected by whether the non-word letter strings were pronounceable. Interference from letters was found for all groups except for a sub-group of 5 early first graders who also had difficulty in a picture-matching task. The findings on the whole suggested that even children who are less skilled readers and normal children with only 9 months of formal reading instruction extract meaning from familiar printed words automatically.

It is important to note that it is not knowledge of color or picture names per se that is related to word identification, but rather the speed with which these color or picture names can be retrieved and produced. Thus, it is not the failure to identify colors accurately but rather the failure to automatize color names for rapid retrieval that is related to learning to read and comprehend passages. Accurate word identification is not sufficient to allow fluent reading. However accurate it may be, if word identification requires most of the reader's attention, it is likely that the comprehension of what is read will ultimately suffer.

Most studies on automaticity have employed performance tasks measured by means of reaction time. However, younger children are a priori 'inferior' in these tasks and consequently their reaction time is longer. One weakness of the Stroop task is that since the longer the reaction time the stronger the interference effect in Stroop-type tasks, the younger children's inferiority in terms of general speed and power become a confounding variable. The Stroop task has also inherited other methodological weaknesses: the subjects might become confused during the task as to whether to attend to the ink or the word. Furthermore, as Guttentag and Haith (1979) argued the naming task might arouse word processing because the preparation for a naming response involves general linguistic mechanisms which may engage in obligatory rather than automatic word processing. One has to be extremely cautious in interpreting the results of research projects employing the Stroop-type method.

CONCLUSION

Though there is still no satisfactory definition of the concept of automaticity, it can be seen as rapid, fluent and effortless processing. The conceptualization of automaticity in reading was elaborated by LaBerge and Samuels (1974) who argued that slow decoding speed would lead to poor comprehension. Hence, automaticity has gained considerable interest and has been a focus of research. The findings of a number of studies (Curtis, 1980; Lesgold & Resnick, 1982; Perfetti & Hogaboam, 1975) do point to the conclusion that generally slow decoders are less skilled comprehenders. Such results, together with the findings of the Stroop-task, are consistent with LaBerge and Samuels (1974) model of automaticity in reading. Stanovich (1982) summarized the findings of a variety of studies investigating children in grades 1 through 6, the correlations between 1) word recognition speed and accuracy and 2) reading comprehension have been consistently in the range of .50 to .80.

One can sum up some of the characteristics of less skilled readers in terms of the notion of automaticity.

1. Less skilled readers show slower lexical access as indicated by their long latency in word matching tasks.
2. Younger and less skilled readers name high frequency words significantly faster than low frequency words and nonwords.
3. Less skilled readers show longer vocalization latencies to isolated printed words and nonwords and this applies to letter strings rather than pictures or digits.
4. Less skilled readers are able to use contextual cues to facilitate word recognition but not comprehension.
5. Even with a considerable amount of practice, less skilled readers could gain relatively slowly in terms of the recognition speed in an isolated word naming task. However, this increase in speed apparently still cannot aid comprehension.

CHAPTER III

READING IN THE CHINESE LANGUAGE: RESEARCH AND MISCONCEPTIONS

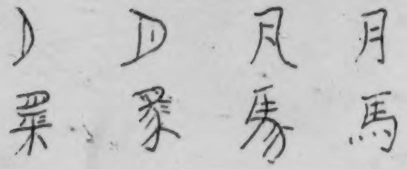
Too often English speaking people tend to think that the alphabetic writing language is the only kind of phonographic symbol system. In fact, there are also other groups of languages, for instance, syllabic as in Japanese, and logographic as in Chinese. The alphabetic and logographic languages represent extremes on most of the dimensions along which writing systems may be compared. In alphabetic writing, symbols represent the phoneme units of speech sound whereas in logographic writing symbols represent linguistic units of meaning. Chinese is an example of logographic writing in which each symbol usually refers to a character 字 (jchî), (the romanization of all Chinese characters in this thesis was based on Cantonese diatect and taken from Robinson, undated) is an abstract conceptualization that stands for an idea, object or quality. The name for 'character' in Chinese is 漢字 (hanzi), named after the Han dynasty which flourished some 2000 years ago. Each character represents a morpheme--the minimum unit of meaning in a language. In English, for example, "hunt" is a morpheme which is a word, but "hunter" has two morphemes of which the "er" morpheme is not a word.

However, in Chinese each character is a morpheme. Terms like pictographic, ideographic, logographic, morphosyllabic and word-syllabic have been used to identify the Chinese writing system. Such a proliferation of terminology together with some general misconceptions on the psycholinguistic properties of the Chinese language have led to more ambiguity on the already mysterious and, as some linguists suggested, opague language (Tzeng & Wang, 1983).

The purpose of this chapter is to identify and correct some common misconceptions on the psycholinguistic properties of the Chinese language. Research dealing with reading in Chinese especially among skilled and less skilled readers will also be reviewed.

Myth 1. The Chinese language is pictorial (Kline & Lee, 1972; Koriat & Levy, 1977).

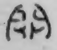
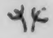
The earliest form of Chinese writing, as incisions on bones and tortoise shells, dates back some 3,500 years. Some of the Chinese logographs may have originated in pictographic or iconic representations; however over the years both the style and structure of the logographs have changed considerably. For example, according to Wai (1961) the characters 'moon' and 'horse' had the following changes:



Few of the modern characters bear any close resemblance to their referent (Wang, 1973).

Traditionally, characters are classified into 六書 (lûk sue) six categories which in turn may suggest the sound and meanings of the characters. It is important to note that these categories of character formation were deduced by scholars studying etymology; this does not mean that such classifications preceded the invention of characters.

1. Pictographs 象形字 are characters based on direct iconic representations and closely resembled the real objects, e.g. 弓 (kung), 'a bow'; 田 (tīn), 'field'; and 月 (yuet), 'moon'.

2. Simple ideographs 指事字 depict the idea or ideas, but not the real objects. They may represent an action or a position, or form a combination to illustrate certain meaning, e.g. 上 (sêung), 'top' and 下 (hâ), 'down'. The character  (hói), 'open' illustrated  two hands pushing against a door 門. The modern version of the character has become 開.

3. Compound ideographs 會意字 indicate an abstract idea by combining two constituent parts as 女 (nŭi), 'girl' and 子 (chí), 'son' together forming 好 (hó) 'good'--when you have sons and daughters then you are

good. The act of 止 stopping an invader from using his 戈 weapon means 武(mǒ) force. Another example is the character 休(yau) meaning rest and formed by combining two pictographs 人, a human being leaning against a tree 木.

4. Phonetic compounds 形聲字 consist of two elements, a signific and a phonetic. The former gives the meaning and the latter provides the pronunciation, for instance, 請 (chíng), 'invite' with 言 as 'word' and 青 as the phonetic; stones which are pure and green are referred to as 碧 (pik), with 珀 as phonetic and 石 'stone' as signific.

5. Phonetic loans 假借字 form by borrowing a homophonous character for writing something that cannot be pictured or indicated graphically e.g. the concepts of number like eight (pàht), nine (káu) existed only in speech; the characters did not exist. Thus the homophonous characters 八 (pàht) and 九 (káu) were borrowed and designated meaning accordingly. Originally, 八 stands for 臂 'upper limbs of human body from shoulder to hand' and 九 stands for 肘 'elbow', all of which had no relation with numbers.

6. Derivative characters 轉注字 have three properties: they have to use a similar radical, are close phonologically and share more or less the same meaning as

通 (tùng) and 達 (dtâht) 'to understand'.

Among the six categories of characters, pictographs because of the resemblance of the shape of the object are closest to being considered as pictorial. However, as the following table may show, pictographs are very limited in terms of the total vocabulary of the Chinese language.

Table 1
Distribution of the Six Categories of Character Formation (Wai, 1961).

Year	1300 B.C.	100 A.D.	1150 A.D.
Origin	甲骨文 Oracle Bones	說文解字 (suet mzn gkahi jchî)	通志 (tung jchi)
Category			
	%	%	%
Pictographs	54.6	3.8	2.5
Simple ideographs	1.0	1.3	0.004
Compound ideographs	10.0	12.3	3.5
Phonetic compounds	34.0	81.2	89.9
Phonetic loans	1.0	1.2	2.5
Derivative characters	0.01	0.001	1.5
Total no. of characters	1007	9475	24235

Early in the Chinese civilization, a large proportion (roughly 55%) of the characters consisted of pictographs. However as time developed ~~more phonetic~~ compound characters were invented; this growing expansion of the phonetic compounds from 34% to almost 90% was matched with a more or less stagnant growth of pictographs. At present, phonetic compounds remain the majority in the Chinese vocabulary, the other categories are quite trivial in terms of their numbers.

The fact that more than 97% of all Chinese characters are non-pictorial makes it quite wrong to describe the language as pictorial; clearly characters are quite distinct from pictures. Characters are not simply pictures; they are, in fact, signs which had been agreed upon and generally accepted as legitimate symbols. The simple lines, curves and even dots highlight the particular features which they represent. For instance, the characters to denote animals are quite simple and would show a side view with the head pointing upward to facilitate writing downward (Tsien, 1975). Yet, characters share with pictures and are different from English words in two aspects. They tend to be visually more complex and varied than their alphabetic counterparts. In addition, they provide direct semantic clues to a construct (e.g. the trunk and branches of a tree form the character for tree, 木).

Myth 2. Characters are arbitrary signs (Cheng, 1977; Gough, 1972; Halle, 1969).

In order to understand more about the Chinese language, one must know about the structure of characters. Each character is comprised of two types of smaller unit--the stroke and the radical. A stroke may be vertical, horizontal, cursive or dot. For instance, the character for 'moon' looks like 月 , which is made up of 丿 冂 冃 月 four strokes. Both the order and the geometric position of the strokes are important. There is a strict sequence in the application of strokes for the majority of characters. In English, the ordering of letters is in a single linear dimension such as tip, pit and ipt. The order that strokes are added plays a significant role in a kind of manual memory for the user. One can often recall a character by tracing it in the air following a fixed order of strokes (Wang, 1981). This fixed order undoubtedly assures a uniformity in the appearance of the characters. The general order is from top to bottom and from left to right. Equivalent strokes when placed differently may create a different character e.g. 玉 (yûk), 'jade'; 主 (jchúe), 'main'; 士 (sî), 'officer'; 土 (tǒ), 'earth'. There are approximately 20 distinct strokes in the language, so that strokes are the closest counterparts to the 26 letters of the alphabet (Wang, 1973). Each character is square in shape, has a fixed length and is formed by different kinds of strokes. The number of strokes in each character varies from one to 52--most characters contain less than 11 (Leong, 1973).

There are no counterparts of the radicals in the orthography of other languages. The traditional set of consist of 214 radicals. Radicals are a kind of semantic classification system. Radicals give meaning to characters and are designed as the "Water Radical" 水(written as 氵), denoting something liquid; the "Tree Radical" 木(written as 木), referring to ideas pretaining to trees or wood. Most radicals are also characters, for example, the 'sun' 日 radical and the character for sun 日 are identical. There are thousands of characters in the modern Chinese language, however, the majority are not radicals.

Characters have the additional features of being balanced and symmetric. Within a character, the width and height of the component parts should be directly proportional to the complexity; that is, the part with more strokes would be higher and/or wider than the subunit with less strokes, hence requiring less space. For instance, 泳 江 河 後, the part with less strokes generally needs 1/3 of the space, with the complex unit requiring the remaining 2/3. If the numbers of strokes within a two-sub-unit character are roughly equivalent, the parts equally share the area, e.g. 打 村. Modern Chinese characters are formed as complexes of about 900 basic units (Zheng & Young, 1980). Examples of different combinations of sub-units are listed in detail in appendix A.

The Chinese language is characterized by the systematic use of strokes, the semantic element of radicals and morphemic basis of characters. An interesting research project was carried out by Koriat and Levy (1977) who required Hebrew speaking subjects with no knowledge of the Chinese language to match pairs of Chinese characters with their corresponding Hebrew words. The findings revealed that the subjects were able to correctly guess the meanings of Chinese characters with better than chance success. This, according to Koriat and Levy (1977), suggests that the choice of orthographic codes to designate concepts is not arbitrary but is governed by figural-semantic association. Thus, it is a misconception to say that the Chinese writing system is arbitrary. It is sufficient to quote Leong (1977): "Chinese script is predicated on the bonding of shape 形, sound 音, and meaning 义, and that the morphemic nature of the symbols helps in their decipherment 望文生义. There is nothing arbitrary about the system" (p. 343).

Myth 3. Written Chinese characters are nonphonetic, and virtually without mnemonic-device possibilities (Biederman & Tsao, 1979; Kline & Lee, 1972; Sheridan, 1983).

In Chinese, each character represents one object, an event or an idea, or more precisely, one morpheme--the smallest meaningful linguistic unit of a language (Taylor, 1981). Characters are monosyllabic. In modern Chinese, 46.4% of the 7,254 characters in Sin Hwa Dictionary are comprised of 3 subunits, and 25.6% of 2 subunits. These subunits tend to carry phonological or semantic clues. Characters that carry phonological units can be pronounced if the structure of the character is analysed, for example, the 丁 ting group of 打 (tá), 'strike'; 訂 (tìng), 'order'; 釘 (teng), 'nail'; and 頂 (tíng), 'top'. Of all the six categories of characters listed earlier, phonetic compounds consist of 82% indicating a good chance of sounding out those characters (Ngahi 艾, as cited in Kao, 1982).

Though there are phonograms in Chinese characters, one has to know how to pronounce the base character in order to sound out the derived phonogram. However, sometimes characters may contain a certain character as their constituent part, but the pronunciation may not be related to that particular character. It has been stated earlier in this chapter that around 90% of the existing Chinese characters are phonetic compounds. However, it is often stated that the Chinese written language is nonphonetic. Given such a high ratio of phonetic compounds such a statement is, thus, not true for most of the characters. According to Zhou (1980), the successful rate of using a base character to sound out another character is about 39%. Another study on the analysis of characters was carried out by Chou 周 (as cited in Wong, 1982) who noted that 98% of Chinese characters have a signific or a base character. Among these characters, 79% sound the same or roughly the same as the signific; while 21% sound differently. Of all characters only 2% stand alone in terms of pronunciation, that is, they have to be rote memorized and there is no clue to search for the pronunciation of these characters. Hence, even primary school children know how to utilize the 有邊讀邊 principle--for unfamiliar character, pronounce the phonetic. When this technique is applied, the successful rate of pronouncing characters is 77%. Though the findings of these studies vary, there is at least one conclusion common to all--a relationship between character shape and pronunication does exist.

It was, therefore, quite erroneous when Sheridan (1983) stated: "Chinese is more difficult to read, since even if a person were already a good reader and came upon an unknown character, he or she would not be able to sound out the character " (p. 82). There is a phonetic principle underlying many Chinese characters. A Chinese reader can often pronounce a character he has never seen before by simply making a guess at its phonetic base (Wang, 1973).

Myth 4. Single Chinese characters are equivalent to single English words (Gillooly, 1973; Nelson & Ladan, 1977; Rozin & Gleitman, 1977).

A view on the level of representation of Chinese orthography is that ~~there is~~ a pattern of a syllable-morpheme-character relationship. In the Chinese language, one character has one sound--monosyllabic. Each character represents a morpheme, so there ought to be as many characters as there are morphemes. However, the same syllable is not necessarily always represented by the same character: individual characters represent different morphemes sharing similar phonemic shapes. This problem of homophones is indeed serious and can be illustrated in the famous story consisting of repetitions of an identical syllable. Sai-si séi sī sèi sẑp sèi which would be unintelligible in speech but when written 西施死時四十四 "Sai-si (a legendary beauty) died at the age of forty-four" would consist of an understandable series of differing characters. There are many characters which are homophones but are represented by different graphemes. Chinese orthography, therefore, seems to represent both the syllabic and morphemic levels of the language, hence the syllable-morpheme-character relationship.

The size of the Chinese vocabulary is rather interesting. The K'ang-hsi Dictionary (1716) lists 42,174 characters while the Chung-wah Dictionary (1915) has 44,908 entries. In daily use, however, the vocabulary is only a few thousand characters. Lin (1980) suggested that the recognition of about 2,500 characters will allow reading of 99% of modern Chinese.

Although many characters are single-character words, characters do not always represent words. The use of 3,000 characters does not mean that the number of words used is restricted to 3,000 because each of the 3,000 characters might combine one or two other characters to form a 'word'. When a word is formed, its meaning may be different from either of the two characters when they are separated. For example, 東 (tung), 'east' and 西 (sái), 'west' may be combined and become a disyllabic word meaning 'the thing'.

In modern Chinese, an increasing number of words are disyllabic and polysyllabic in nature (Lee, 1976).

The combination principle is based on semantic consideration rather than on phonetic consideration. For instance, 好奇心 'curiosity' consists of three different characters. The first one 好(ho) means 'good', the second 奇(kei) means 'strange' and the third 心(szm) means 'a heart or mind'. Together, they mean 'a heart which has good intentions for strange items'--curiosity.

Since one-character words are mono-syllabic, words formed with more than one character are polysyllabic. According to Ai (1950) the number of polysyllabic words is about six times more than that of monosyllabic words. A survey carried out by Yi (as cited in Lee, 1976), examined a 210,140-character corpus of primary school texts also found a polysyllabic/monosyllabic word ratio of 6:1. Ai (1950) counted the number of characters and words in various readers used in primary schools in China; the number of different characters was 2,236 while the number of words was 6,819. More recently, Liu, Chuang and Wang (1975) carried a frequency count of characters and words in daily use in Taiwan, finding that the number of characters was 4,532 and the number of words was 40,032. In sum, a great majority of Chinese characters are disyllabic and polysyllabic in nature and thus are not equivalent to single English words.

Myth 5. The Chinese language has little or no grammar.

If grammar is defined in the narrow sense as having inflections of persons, case, number, tense and so on, the Chinese language really has no grammar. For instance, in English the time element is indicated in the verb (like go, went, gone) and changes when required. In Chinese, the character 走 (go) is used to show the three types of time elements. This character remains the same regardless of the syntactical structure of the sentence. This uninflectional feature makes the Chinese language quite different from other orthographies. But there is as much orderly organization of parts into wholes in Chinese as in any other language. In Chinese, endings such as those indicating tense or number are not added directly to characters but instead are either inferred from context or explicitly stated by adding in separate characters.

Besides the regular structure in word formation which was mentioned earlier, there is distinction of parts of speech:

人 (yz̄n) 'human being' is a noun.
來 (loi) 'come' is a verb.
綠 (luk) 'green' is an adjective.
他 (tá) 'he' is a pronoun.

The isolation feature of the Chinese language allows more flexibility in grammatical categories. The same character 明 (mīng) in different combinations may serve different grammatical functions. Thus, in 明月 (mīng yuet), 'bright moon', 明 is an adjective; in 明白 (mīng pâhk), 'understand', it is a verb; in 明日 (mīng ŷzt), 'tomorrow', 明 is a noun; in 說明 (sùet mīng), 'state clearly', it is an adverb.

The Chinese language also has functional significance in word-order:

adjective-noun	美麗的妻子	beautiful wife
verb-object	收信	receive letter
subject-predicate	他是個傻人	he is a fool.

As in English, the basic sentence in Chinese also has the subject-verb-object order. For instance, the character 我 (ngǒh), 'I' can be a subject in 我愛你 (ngǒh oì něi), 'I love you'. The grammatical values of characters are determined by the position they occupy in a sentence. Thus, in 你愛我 (něi oì ngǒh), 'You love me', 我 serves as an object.

In sum, Chinese is an uninflected language, it has grammar.

Myth 6. Reading disability is a rarity in ideographic language (Kuo, 1978; Makita, 1968).

The problem of reading disability is pervasive in the English language and the prevalence rate among school children has been estimated from 3 to 15 percent (Meier, 1971; Sheridan, 1983). The rarity of reading disability has been noted in languages adopting syllabary and logographic systems (Kuo, 1978; Makita, 1968). In a study conducted by Makita (1968), who surveyed 247 primary teachers of 9,195 children in Tokyo, the teachers were asked to report on the number of children in their classes who had difficulty reading Kana (syllabic scripts) and Kanji (logographic scripts--Chinese characters as being used in Japan) scripts. Results indicated that less than 1% of the children had reading difficulties which is far less than the rate in Western nations. There was also a decrease in the incidence of children experiencing difficulty with Kana scripts by grade level. None was reported beyond fourth grade. However, children were having difficulty with Kanji scripts all through elementary school, though only 0.4% of the children had difficulty at fourth grade and above. Makita (1968) then concluded that dyslexia are virtually non-existent in Japan.

Kuo (1978, as cited in Tzeng and Hung, 1980) also carried out a similar survey in Taiwan and found that the number of children experiencing reading difficulty is minimal. Though the findings of these research studies seem impressive, one should be cautious in interpreting the results reported. In Taiwan, literacy is highly valued and great social pressure is imposed on schools to make them appear successful. A simple survey on reading disability would be inadequate in showing the whole picture (Tzeng & Hung, 1984). Furthermore, in Chinese there are no characters whose meaning is equivalent to the term 'reading disability'. The concept is very difficult for Chinese people to understand. Difficulty in reading would be attributed to lack of proper training and poor motivation (Stevenson et al., 1982). Hence, evidence provided by Kuo (1978) should not be interpreted too enthusiastically.

A more thorough cross-cultural investigation carried out by Stevenson, Stigler, Lucker, and Lee (1982) suggested that roughly about 8% of Chinese elementary school children could be classified as reading disabled. The incidence of English speaking children with reading difficulties estimates range from 3% to 15% (Meier, 1971). Thus Stevenson et al's research not only shows that there are reading disabled Chinese school children, but also stresses that the estimated incidence of reading disabled children among the Chinese population is compatible with the estimate in the English population. In a study of 277 bilingual Chinese children who were simultaneously learning to read and write English and Chinese, Kline and Lee (1972) found that the incidence of subjects having difficulty learning Chinese, English or both languages was 13%, 9% and 6% respectively. Combining figures, the total having difficulty with English was 15%, and the total having difficulty with Chinese was 19%. Considering the error of measurement, these differences are not felt to be significant. Kline and Lee's (1972) findings tend to suggest that incidence of reading disability occurs among children reading English as well as children reading Chinese.

RESEARCH IN READING CHINESE

As a sound-writing script, the English alphabetic system maps onto speech at the level of phoneme--a linguistic unit smaller than the syllable but larger than an articulatory feature. According to Chomsky (1970), the English orthography represents linguistic knowledge on a phonological and a morphological level. The same sound can often be represented by different letters, for instance, there are at least 20 different ways of spelling the sound "eve" (Gillooly, 1973). The selection of letters will depend on a morphological basis. Hence, the grapheme--sound relation embedded in the English alphabetic system is marked as a morphophonemic representation. As a result, English orthography is a phonologically deep writing system and the grapheme-sound relation is somewhat opaque, which has been seen as a barrier to the acquisition of reading. There is an important contrast between logographic and alphabetic scripts with reference to how symbols are put together to represent the spoken language ~~graphically.~~ In English, a word consists of a number of subunits, each of which has a semantic and/or phonetic function. For example, the word 'mountain' can be decomposed into one morpheme plus 'ain', two syllables, six phonemes, six spelling units and eight letter (Taylor, 1981). Thus, English words are decomposable into a few levels of subunits, whilst its Chinese equivalent 山 "shan" is one morpheme, one syllable and one character, which defies decomposition into subunits. Perceptually, the grapheme-sound mapping in Chinese is discrete. In the English script the relation is continuous and at a more abstract level.

Such a difference has important implications for readers at the entry level in the two scripts. The written array in Chinese is dissected syllable by syllable and clearly has a one-to-one correspondence with the syllablic boundaries of the spoken language. In the English system, because of the multi-level representation, children may have to go through a morphophonemic process in which words are first parsed into morphemes, and then symbol-sound relations are applied (Venezky, 1970).

As Chinese characters and alphabetic words differ in the way they appear, code sounds and map meanings, it seems reasonable to suggest that human information processing may differ because information is presented in different orthography (Tzeng, 1981). At the theoretical level, Chinese characters are meant to represent meanings primarily and sounds secondarily, while English words are meant to represent sounds primarily and meanings secondary (Leong, 1978; Taylor, 1981; Wang, 1973; Wong & Weber, 1984). Such theoretical speculations have led researchers to engage in studies of information processing in the logographic language (Biederman & Tsao, 1979; Hoosain & Osgood, 1983; Park & Arbuckle, 1977; Tzeng, Hung & Garro, 1978).

Most children learn to read English by learning to produce sounds in response to printed materials, and to derive meaning from the materials by listening to the sound they produce. Morrison (1981) proposed that children may experience reading problems because of their difficulties in mastering the complex, irregular system of rules governing symbol-sound correspondences in English. There seems to be some evidence for such a type of reading disabled children. Results from studies attempting to teach English speaking children to read logographic scripts have been most interesting.

Learning Chinese is Simple

Rozin, Poritsky and Sotsky (1971) taught a group of Philadephia second-grade school children with serious reading problems some logographic scripts--Chinese. They hypothesized that since Chinese characters have a one-to-one correspondence from sound to meaning, children do not need to break down the word into phonemes in order to sound it out. Consequently, they should be able to read Chinese with little problem. The findings seem to support their hypothesis. Rozin et al. (1971) attributed the success of their program to the fact that Chinese characters map into speech at the level of words rather of phonemes. Though the findings may at first glance seem interesting, a scrutiny makes the results less impressive. The subjects in the experiment consisted of only 9 children with reading difficulties. Individual teaching sessions were carried out 2 to 3 times a week for a period of three months. A total of 30 Chinese characters were successfully learned. However, it must be emphasized that even if these children were to learn at such a rate, a mere total of 120 characters would be learned annually. At grade six, they would presumably acquire only about 600 characters which is still far from a vocabulary of 3000 characters which an average grade six Chinese pupil would have learned. A note of interest is that Rozin et al's work was by no means new. Hinshelwood, back in 1917, had reported the suggestion of Bishop Harmon in using Chinese characters in teaching dyslexic children because Chinese is a sign script in which each word is represented by a symbol (Hung & Tzeng, 1981).

Results from another study employing logographs also indicated that poor English comprehenders do not have difficulty in learning that a symbol can stand for a word meaning (Denner, 1970). Subjects could easily act out the meaning of individual characters. However, when asked to act out the meaning of individual characters, the children continued to treat each symbol as a separate entity, unmodified by the characters around it. Denner's results seem to run counter Rozin et al.'s (1971) research.

In another study conducted by Nelson and Ladan (1977), who required good and poor English second grade readers to make a same-different decision on pairs of Chinese characters presented successively, found that poor readers produced significantly more errors than did good readers. On the basis that poor readers tend to approach the task of discriminating words by reducing wholes to parts and may experience difficulty in resolving letter units into phonemic elements, Nelson and Ladan (1977) recommended the use of Chinese characters as intermediaries in order to provide an easier means than alphabetic scripts to synthesize a word without engaging in phenemic analysis. However, they concluded that cognitive explanations are not sufficient in explaining the efficacy of Rozin et al.'s (1971) method. It appears that perceptual factors may play an important role in not only distinguishing skilled and less skilled readers but also serving to reinforce the use of Chinese characters as intermediaries in introducing reading.

Park and Arbuckle (1977), completed an experiment to examine how Korean subjects memorize words written in the two writing systems--one alphabetic and the other ideographic (Chinese characters)--as being used in Korea. Results showed that words presented in logographic script were remembered better than words presented in alphabetic script on recognition and free recall. Furthermore, in mainland China, all elementary school children learn to read Chinese characters and the Pinyin system (pronunciation based on the Latin alphabet) simultaneously. At the end of grade one, children had spent more time learning the Pinyin system than learning characters. Zeng (1984) examined the errors made in dictation and found that there were more errors in writing Pinyin than in writing characters. Zeng concluded that Chinese characters were easier to learn, to memorize and to write than the Pinyin system. Results from Nelson and Ladan (1977), Park and Arbuckle (1977), Rozin et al. (1971) and Zeng (1984), generally indicated that subjects may process information differently depending on the orthography--Chinese being relatively easy to learn than the alphabetic writing system. However, it seems fair to say that at this stage because of the limited research carried out in this area, the findings are still inconclusive and await further research to shed light on this issue.

Automaticity and Reading in Chinese

Tzeng, Hung and Garro (1978) even went as far as to postulate that skilled readers in a logographic system may prefer the visual route, that is they may go directly from orthographically coded information to meaning. In other words, skilled Chinese readers may be more automatic in processing reading materials. Some empirical evidence has been reported. In an experiment carried out by Biederman and Tsao (1979), 16 Chinese university students and 16 English-speaking subjects were tested. The results showed that the Chinese subjects were slower than the English speaking subjects on Stroop tasks--naming colors when the colored ink spelled the name of a conflicting color. Apparently, in the Stroop tasks, it is more difficult for Chinese subjects to ignore the meanings of color names than it is for English subjects to ignore the meanings of color names in English. Biederman and Tsao suggested that a reader in an alphabetic writing system cannot refrain from applying an abstract rule system to the word. Though a reader of Chinese script may have to go through a configurational processing of the character, Biederman and Tsao (1979) concluded that Chinese characters permit more direct access to meaning than an English word. Hence Chinese is more potent than English orthography in producing Stroop-test interference.

Although this study has some important cross-cultural research implications, it suffers from several methological weaknesses. First, there were significant subject differences in the reaction times required to name the colors of simple color patches. The mean reaction times of the Chinese subjects, for some unknown reasons, were relatively slower ~~overall. Se~~cond, the Chinese subjects in the study were semibilingual, whereas the American subjects were monolinguals. Third, Chinese color terms are all monosyllabic characters, but in the English system this is obviously not true.

In another Stroop-test experiment (Fang, Tzeng, &

Alva, 1981), bilingual subjects were employed and were asked to choose words printed in different languages known to them. Results indicated that the mean reduction of Stroop interference with Chinese-English languages was 213 msec. and French-English languages was merely 33 msec. These findings demonstrated that there is a relation between the amount of interference and the degree of similarity between the two scripts used. Such results are consistent with Biederman and Tsao's findings suggesting that logographic scripts produce greater interference than alphabets.

Hoosain and Osgood (1983), employing the reaction time methodology, also found a significant difference in processing times for English and Chinese words. American subjects and Chinese subjects were asked to judge the positive/negative affective polarity of words in their respective languages. Response times for Chinese were significantly faster. In a reaction time study employing Chinese and English subjects, So, Potter, and Friedman (1976) required subjects to name characters and to classify them according to meaning. The findings indicated that the naming of Chinese characters was faster than the naming of pictures and English words.

In a study to compare speech recoding in silent reading among native Chinese and English speakers (Treiman, Baron, & Luk, 1981), subjects were given a list of sentences in their own language and made judgments of the sentences' truth or falsity. Performance on two types of false sentences were compared: one contained a homophone word such that the sentence would sound true if read aloud (homophone sentence) and another that did not (control sentence). Results demonstrated that English readers took longer and made more errors on homophone sentences, and Chinese readers were significantly less impaired by homophone sentences relative to control sentences. Such results suggest that speech recoding is used less by Chinese readers; a more visual from print to meaning path may have been employed by the Chinese readers than English readers.

Results from Stroop color-word test (Biederman & Tsao, 1979; Fang et al. 1981), word processing test (Hoosain & Osgood, 1983) and silent reading tasks (Treiman, Baron & luk, 1981), have shown some indirect support for relatively more visual involvement in the processing of Chinese characters. Consequently, Chinese characters may have more direct--and therefore faster--access to the internal lexicon. At this stage, it is reasonable to conclude that skilled Chinese readers can process Chinese characters faster than skilled English readers in processing English words. However, would skilled Chinese readers process characters faster than less skilled readers?

Hung, Tzeng, Salzman and Dreher (1984) attempted to answer the question and tested 20 skilled and 20 less skilled university students with Chinese as their first language. Results showed that all subjects recognized high frequency words faster than low frequency words, skilled Chinese readers having faster decoding speed than less skilled readers on both high frequency and low frequency words. In interpreting these results, it is important to note that the subjects were classified according to their processing time in reading aloud a passage--the skilled readers being 3 minutes and 44 seconds and the less skilled readers being close to 9 minutes on average--and not by the comprehension ability. Naturally, with such a large discrepancy in reading time for prose, it is reasonable and, in fact, expected to find that the naming time of individual words for less skilled readers would be significantly slower.

It is noteworthy that the subjects employed in most studies concerning language processing in Chinese (Biederman & Tsao, 1979; Cheng, 1981; Hoosain & Osgood, 1983; Hung et al., 1984) were limited in number and were all university students. It is doubtful whether the results could be interpreted and generalized to reading especially at the elementary level where most learners experience reading difficulties. Such studies are particularly insufficient in helping one to examine the developmental aspects of reading difficulties.

Pattern of Recognition

In research on the pattern of recognition of Chinese characters among 'normal' subjects, Ai (1955) demonstrated that characters with less than 10 strokes are better recognized after short exposure. Characters with more than 10 strokes are better recognized if they are formed from horizontal or vertical lines, or are symmetrical, or closed forms. Characters with a high stroke number and which contain oblique lines or gross asymmetry are difficult to recognize.

Cheng (1982), required 32 university students to process stimulus words presented on the screen at 1/150 second. The subjects were then asked to choose one of the two responses in the next slide whether the stimulus words had occurred or not. Results show that characters with fewer strokes are recognized more easily (68.75%) than characters with more strokes (53.65%). Characters are more easily recognized when embedded in 2-character words than 2-character nonwords. Also, characters are more easily recognized than pseudo-characters and non-characters, while high frequency and low frequency characters had no effect on their recognizability. On one hand such results are consistent with the word-length effect as reported in the English studies, but on the other hand they are conflicting with the word-frequency effect as reported in studies using English words as stimuli (Ruberstein, Garfield & Millikan, 1970). In interpreting Cheng's (1982) findings, it is interesting to note that even for characters with fewer strokes the accuracy of recognition was only at around 69%. Perhaps a more appropriate method is to measure the reaction time in response to certain stimuli in some lexical decision tasks.

Researchers have also looked into the particular orthographic characteristics of the Chinese language on information processing. Yeh and Liu (1972) studied the elements of meaningfulness, strokes, subunits and structures of characters. Based on these elements, a total of 72 characters were selected. Stimulus words were rapidly shown to subjects. Results indicated that characters with more strokes have a high recognition threshold, while characters with less strokes have a low recognition threshold. Characters with high meaning value were shown to have a low recognition threshold and characters with low meaning value have a high recognition threshold. The recognition of Chinese characters is strongly influenced by the number of strokes and meaningfulness of a character rather than the structure and subunits within a character.

CONCLUSION

Though a lot of material has been written on the Chinese writing system, misconceptions on the psycholinguistic properties of the Chinese language still prevail. It is important to remember that:

1. Chinese characters are not pictorial.
2. Chinese characters are systematic signs, with semantic and morphemic components embedded in the structure.
3. Characters may also carry sound specifications--with phonological components within a character.
4. Single Chinese characters are not the equivalent to single English words.
5. Written Chinese has grammar.
6. Like with any languages, reading disability also exists among Chinese readers.

On the whole, relatively few research studies have been carried out in the area of reading in the Chinese language. Even in research relating to reading Chinese, researchers have tended to employ fluent adult readers as subjects; consequently such results could hardly be generalized and would not further the understanding of reading problems in early grades among the Chinese population. Studies dealing with reading problems among Chinese elementary school children are noticeably lacking. With the exception of Hung et al. (1984), no researchers have explored the relationship of decoding speed and reading ability among Chinese subjects. No study has yet examined the relationship between decoding speed and Chinese reading comprehension ability. It is true that a lack of information can lead to misunderstanding. In view of the limited research on the information processing model of reading in the Chinese language, the study will attempt to look into the following questions:

1. Would skilled readers have faster decoding speed than less skilled readers in Chinese character recognition tasks?
2. Do readers require more time to process complex Chinese characters and words than simple characters and words?
3. Would younger and less skilled readers take longer to decode low frequency than high frequency characters and words?
4. Would the relationship of decoding speed and reading comprehension ability change as readers develop?
5. Does decoding speed make an independent contribution to the prediction of reading comprehension ability?

CHAPTER IV

METHODOLOGY

In most models of reading, word identification is initiated by graphemic encoding of the word, and access to word meaning is then achieved either directly from this graphemic code or via a phonological one (Goodman, 1970; McCusker, Hillinger & Bias, 1981). In other words, a reader can translate directly from graphemes into meaning or mediate from graphemes into phonemes and then to meaning. When access to these word codes occurs automatically, as suggested by the model of automaticity in reading, it does not compete with other reading processes for available processing capacity. When decoding is not automatic, competition among reading processes may result, and there may not be enough resources for all necessary processing. In order to shed light on the concept of automaticity in reading, it is indeed important to compare the graphemic and phonological coding speeds of both skilled and less skilled readers.

In this thesis, the importance of decoding skill has for reading comprehension was assessed by comparing the performance of less skilled readers at two different ages to performances of skilled readers similar in age. Developmental differences were observed by comparing the decoding skill of readers of different ability levels and at two different age levels. In order to determine whether the subject could automatically recognize a stimulus--in this case, a Chinese character, a pair of characters was presented at a moment when he was not expecting them (LaBerge & Samuels, 1974). Thus, decoding speed was operationally defined as the reaction time required to identify or recognize a pair of stimuli in a same/different decision task. Furthermore, decoding ability was divided into graphemic coding speed and phonological coding speed and studied separately. Graphemic coding speed was measured with a simultaneous matching procedure in which the time to decide whether visually presented stimuli were the same or not was measured. Phonological coding speed was recorded by means of a vocalization task in which time to begin vocalizing the name of a stimulus was measured. Two types of stimuli (characters and two-character words) permitted comparisons in coding speed between single-graphemic and multiple-graphemic stimuli.

Since components other than decoding speed could result in reaction time differences on the naming task, two other tasks were included. The first task was a visual pattern matching task whereby subjects were required to make a same/different decision on simultaneously presented dot patterns that were non-verbal in nature. Skilled readers by virtue of their superior ability in terms of phonological ability and sheer size of vocabulary might be faster than less skilled readers in the character matching tasks. In fact, in research projects involving English speaking subjects, Vellutino (1979) had repeatedly shown that there was no visual processing difference between skilled and less skilled readers which was apparent when unfamiliar stimuli were substituted for letters and words: visual processing deficits on the part of less skilled readers disappeared. Hence, in the absence of a deficit in visual processing skills, the failure of comprehension among less skilled readers may be due to deficits at the graphemic and/or phonological levels. Thus a task, in order to detect the decoding ability of the subjects, had to eliminate the element of possible speech recoding, while at the same time being unfamiliar to the subjects. The speed in the dot patterns matching task was a better indicator of decoding ability uncontaminated by phonological processing and memorization strategies (e. g. verbal rehearsal). Dot patterns matching must be accessed via a graphemic processing strategy since phonological coding will not work for dot patterns. If the differences of achievement in the comprehension of text could result only from a phonological deficit on the part of the less skilled subjects, then the skilled and less skilled subjects should not differ in the graphemic processing task such as the dot matching task. The second task required the subjects to examine a Chinese character for a few seconds before pronouncing it. This allowed measurement of latencies for production of character name after graphemic and phonological code access had occurred.

As the linguistic properties of Chinese and English languages are so different it is worthwhile to study whether or not different orthography might affect human information processing. Repeatedly, research have shown that skilled readers can recognise words faster than less skilled readers. Would it be the same if the stimuli were Chinese? Studies in the alphabetic script have shown that readers generally need more time to decode increasingly longer words, especially so in the early grades. In the Chinese language, each character occupies the same amount of space; in other words, there are no "lengthy" characters. It is, however, interesting to ask: Would it take longer to decode a character with more strokes than a character with less strokes? Would word frequency still have its effect on Chinese character recognition? Would the speed of decoding be different for different cohorts? The major research problem in this thesis is: How does decoding ability affect one's ability to comprehend what is read? In order to further examine LaBerge and Samuels (1974) theory of automaticity in reading, the present author hypothesizes that:

1. with similar chronological age, skilled readers have faster decoding speed than less skilled comprehenders.
2. two-character words with more strokes require more time to decode than single characters with fewer strokes.
3. low frequency characters and words require more time to decode than high frequency characters and words.
4. decoding speed increases as a function of age.
5. factors predicting reading comprehension ability are different for skilled and less skilled readers.

METHOD

Subjects and Design

Subjects were 80 children from primary two and four (equivalent to grade 2 and 4) of one school in urban Kowloon, Hong Kong. The first language of all subjects is Cantonese. Within the total sample there were four groups of subjects, each of which consisted of 20 children. Teachers were requested to select skilled as well as less skilled readers on the basis of their reading achievement from primary 2 and 4 classes. The first group was composed of skilled primary 2 readers (11 girls and 9 boys; Mean age = 8 years 3 months) with an average reading level of 3.07 (range 2.33-3.83 and standard deviation = 0.37) as indicated in the Informal Chinese Oral Reading Comprehension Test (constructed by the present author and listed in full in appendix B). No formal Chinese reading and oral reading comprehension tests like the Wide Range Achievement Test and Safran's Rapid Reading Test were available. The other group of skilled readers included primary 4 pupils with a average reading level of 5.45 (range 4.75-6.87 and standard deviation = 0.670). The remaining two groups consisted of subjects whose grade levels in reading were below their grade levels. The less skilled readers' group consisted of primary two pupils (9 girls and 11 boys; Mean age = 8 years 5 months) and primary 4 pupils (3 girls and 17 boys; Mean age = 10 years 10 months). The average reading level of the former was 0.79 (range 0.17-1.75 and standard deviation = 0.521), while the latter was 2.03 (range 0.75-3.25 and standard deviation = 0.615). The reading levels of the skilled readers were on the average above their grade level, whilst the less skilled readers were on the average 2 years below grade level as indicated by their reading comprehension scores. No subjects were classified as being mentally retarded.

The passages of the Informal Chinese Oral Reading Comprehension Test were selected from commonly available textbooks from kindergarten to primary six level. With the exception of primary five and six where there is only one passage, there are two passages at each level; one was relatively more difficult than the other. All subjects began reading at kindergarten level. The subjects read each story aloud and their reading times were recorded. Substitutions of words were also counted as errors. On finishing a story the subject was asked the accompanying six questions (two on fact, two on inference and two on vocabulary). Subjects continued reading the passage at each successful level until their reading errors exceeded five or until the percentage of questions answered correctly dropped below 50%. At this point oral reading was stopped, and the subject was assigned the primary reading level of the immediately preceding passage.

Matching

In the name matching tasks, the subjects were shown pairs of stimuli simultaneously and were asked to indicate if the stimuli match (e.g. 二 and 二) or not (e.g. 上 and 下). The subjects were to respond to the stimuli as quickly as possible by matching the stimuli through pressing two telegraph keys--one indicated YES meaning that the stimuli were the same or No, that is, the stimuli were different. The reaction time, defined as the time interval that has elapsed between the presentation of a stimulus to a subject and the subject's response, was recorded by an Apple II computer. The stimuli in the matching tasks consisted of high frequency characters, low frequency characters, high frequency words, low frequency words, and dot patterns. The character and word items are shown in appendix C. Since Chinese is read from top to bottom (Chen, 1981), pairs of items of each trial were presented one on top of the other separated by 4-cm. To insure name rather than physical identity matching, the top item in the character and word pairs appeared in print one size larger than the lower one.

The high frequency character pairs were simple Chinese characters such as 二 yi, "two"; 大 tahi, "big"; 上 sêung, "top"; and 日 yzt, "sun". Some examples of the high frequency character pairs are as follows:

Match		Different	
二	大	上	日
二	大	中	冷

The character pairs consisted of the 60 most frequently used characters out of a corpus of 753,941 occurrences of 4,864 Chinese characters. The average frequency of occurrence per character in the entire corpus was 155 (Suen, 1979). The high frequency characters had printed frequencies ranging from 1944 to 26,738 with an average frequency count of 4058. These characters were known to all subjects. The average number of strokes for the high frequency characters was 6.8.

The low frequency character pairs consisted of characters like 乞 hzt, "beg"; 弓 kung, "bow"; 欠 him, "owe"; 症 ching, "disease". Some examples of the low frequency character pairs are shown as follows:

Match	Different
乞 弓	欠 症
乞 弓	池 沙

The stimuli consisted of 60 Chinese characters selected on the following two bases:

a. characters had to be below the frequency occurrence of 155 which was the average occurrence per character in Suen's (1979) survey.

b. individual characters had to be as close as possible so as to match the number of strokes of a particular character in the high frequency character group.

Attempts in matching the low frequency characters with the high frequency characters in terms of the number of strokes would eliminate strokes as a confounding variable and would help to differentiate the two character groups on the basis of frequency of occurrence. The average number of strokes for high frequency characters and low frequency characters were the same at 6.8 each. The low frequency characters had printed frequencies ranging from 1 to 153 out of the corpus of 753,941, and with an average frequency count of 39. The subjects knew the meaning of some of the characters but not necessarily all.

The high frequency word pairs consisted ~~of~~ words like 家庭 ka ting, "family"; 知道 chi to, "understand"; 國家 kwok ka, "nation"; 時候 si hau, "time". Some examples of the stimulus pairs are as follows:

Match		Different	
家 庭	知 道	國 家	時 候
家 庭	知 道	先 生	表 示

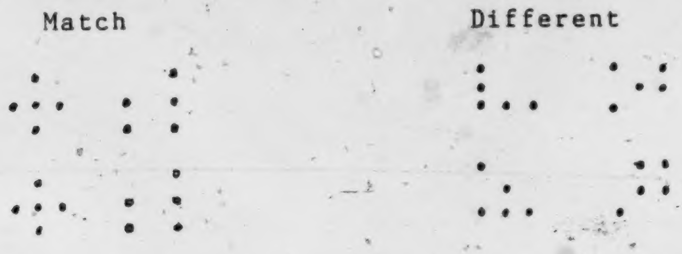
The high frequency word pairs were selected from the most frequently used two-character words out of a corpus of 1,000,000 occurrences of 40,000 Chinese characters and words (Lui, Chong, & Wang, 1975). The high frequency word pairs had printed frequencies ranging from 3012 to 372 with an average frequency count of 769, whereas the average number of strokes for the high frequency word pairs was 16.6.

The low frequency word pairs consisted of words like 波動 poh tung, "turbulence"; 道義 to yi, "righteousness"; 倒數 to so, "countdown"; 漁業 yue yip, "fishing industry". The following are some of the stimulus pairs of the low frequency words:

Match		Difference	
波	道	倒	漁
動	義	數	業
波	道	童	汽
動	義	年	水

The low frequency word pairs consisted of 60 randomly selected words below the frequency occurrence of 60. The low frequency word pairs had printed frequencies ranging from 52 to 1 with an average frequency count of 9.7, while the average stroke number was 17.6.

The dot patterns were generated by randomly filling in five dots in a 3 X 3 matrix. The different pairs were formed by moving one dot in a given column one row over relative to the original pattern. Each pair of dot patterns was unique and therefore no set was ever repeated. The following are some examples of the dot patterns matching pairs:



The stimuli for all of the matching tasks were printed and photographed for slides. They were projected with a Kindermann LKM projector on a rear projection screen, appearing black on a light green background. In the matching tasks, each character and dot pattern was approximately 2 cm x 2 cm with a 4-cm separation between items in a pair. The opening of the projector's shutter started a clock in an Apple II computer, which stopped and recorded the response latency when the subject pressed the telegraph key. The clock internal to the Apple was accurate to less than 1 msec.

Vocalization

The stimuli in the vocalization tasks were high frequency characters which were selected from the same sources as described earlier in the matching tasks. However, instead of a pair of Chinese characters, in each instance only one character was available e.g. 犬

tahi. "big"; 二 yi, "two". The stimuli, are the 30 most commonly used characters in the Chinese language, had long been known to all subjects. Thus, rather than testing the vocabulary knowledge of the subjects, well known Chinese characters were provided so as to assess the speed of vocalizing such stimuli. The subjects should master the skill of vocalizing these characters effortlessly with rare errors. As the stimulus appeared at the centre of the screen, the clock started with the opening of the projector's shutter and stopped at the subject's initial vocalization via a voice-operated relay.

PROCEDURE

Subjects were tested individually for two sessions. The first session consisted of the reading and comprehension tasks; the second session consisted of the matching and vocalization tasks. In the first session, subjects were told they would participate in a reading game with a computer. The order of presentation of stimuli was the same for all subjects. Instructions given to the subjects were all in Cantonese--the predominant Chinese dialect in Hong Kong. Subjects were seated comfortably approximately two feet before a rear projection screen with their preferred hand position in front of two telegraph keys, one marked YES and the other marked NO (in Chinese). The subject was instructed in Chinese to respond as quickly as possible in all tasks.

Matching

There were a total of 70 trials on each of the stimuli types--high frequency characters, low frequency characters, high frequency words, low frequency words and dot patterns. The first ten items were for practice. Of the 60 test trials on each type, 30 were "same" pairs and 30 were "different" pairs. The test pairs with each type were presented in random order and the order of stimulus types was the same for all subjects (i.e. high frequency characters, low frequency characters, high frequency words, low frequency words, and dot patterns). Subjects were instructed to press the YES key if both items in the pair were the same and to press NO if they were different. They were told to respond as quickly as possible. Matching latencies were recorded as the time elapsing between the opening of the projector's shutter (which started a clock operated in an Apple II computer) and the subject's response by pressing the key.

Vocalization

There were two types of the vocalization tasks.

In the first type, there were 35 trials each with high frequency characters, the first ten of which were warm-up trials. The stimuli were presented one at a time in the center of the screen. Subjects were told to look at each item and to say it out loud as soon as they knew its name. The items would disappear as soon as they began vocalizing. All subjects saw the same stimuli in the same order, and latency was recorded as the time elapsing between the shutter's opening and the subject's initial vocalization.

In the second type of vocalization task, the high frequency characters were presented again. This time the subject had to wait before saying the character. Each character remained on the screen for approximately three seconds and was immediately replaced by a blank slide with a red dot in the centre. Subjects were instructed to then say the character's name out loud as quickly as possible when the red dot appeared. The time elapsing between the opening of the shutter for the blank slide and the subject's initial vocalization was recorded as the latency for articulating the character name.

CHAPTER V

RESULTS

Performance on the lexical decision name matching and character vocalization tasks was quite accurate in all groups. Mean mistakes and error rate in terms of percentage are presented in Table 2. Matching accuracy for all groups was around 94%; however, t-test calculations among different means were non-significant (p > .05).

Table 2
Mean Mistakes Among Tasks for Each Sub-group

	Skilled readers		Less skilled readers	
	Primary		Primary	
Task	2	4	2	4
	%	%	%	%
HFCMS	3.08(6.2)	2.25(4.5)	2.28(4.6)	1.6(3.2)
LFCMS	2.69(5.4)	2.25(4.5)	2.72(5.4)	1.5(3.0)
HFWMS	2.92(5.9)	2.88(5.8)	2.17(4.3)	1.8(3.6)
LFWMS	3.15(6.3)	4.50(9.0)	2.67(5.3)	2.9(5.8)
DMS	5.15(10.3)	5.38(10.8)	6.33(12.7)	4.4(8.8)
CVS	0.62(2.5)	0.88(1.8)	0.94(1.9)	1.2(4.8)
CPS	0 (0)	0 (0)	1 (2)	0.6(2.4)

Note. HFCMS=High frequency characters matching speed; LFCMS=Low frequency characters matching speed; HFWMS=High frequency words matching speed; LFWMS=Low frequency words matching speed; DMS=Dots matching speed; CVS=Characters vocalization speed; CPS=Characters production speed. For sub-group, n = 20.

In vocalization tasks, 98% of the characters were correctly identified by the primary 2 children. The vocalization accuracy for the less skilled primary 4 group was around 95%; when compared with all other groups, this mean accuracy was also non-significant ($p > .05$). Median latencies for correct responses were calculated for each subject on each of the tasks. Reciprocal transformation of the latencies was performed to reduce distortion resulting from problems of positive skew or unequal group variance. All analyses were performed on these speed scores.

Group means on each of the basic measures are shown in Table 3. All means are based on 20 subjects. A 2 X 2 (by grade and by skill) analysis of variance on each task is listed in detail in Tables 4 to 11. Results of the analysis of variance indicated that the grade effect was significant on each measure ($p <.001$) except on character production speed; only the skill effect was significant [$F(1,76)=7.677$, $p <.007$].

The grade level effect and skill effect on reading comprehension level were significant, [$F(1,76)=212.07$, $p <.001$], and [$F(1,76)=525.96$, $p <.001$], respectively. The 2-way interaction between grade level and skill on reading comprehension level was significant, [$F(1,76) =20.92$, $p <.001$]. In all cases the direction of the

Table 3
Mean Performance on All Tasks

	Skilled readers		Less skilled readers	
	Primary		Primary	
Measure	2	4	2	4
Reading comprehension level	3.07	5.45	.79	2.03
High frequency characters matching speed	1.25^{a}	1.67	1.01^{a}	1.34^{a}
Low frequency characters matching speed	1.14^{b}	1.56^{a}	$.93^{b}$	1.13^{ab}
High frequency words matching speed	$.98^{a}$	1.42	.78	1.03^{a}
Low frequency words matching speed	$.91^{a}$	1.22	.74	$.96^{a}$
Dots matching speed	$.76^{a}$	.99	.62	$.82^{a}$
Character vocalization speed	1.53	1.84	1.29^{a}	1.40^{a}
Character production speed	3.66^{a}	3.73^{a}	3.12^{b}	2.93^{b}

Note. Values that share a common superscript in each row do not differ significantly ($p < .05$).

differences indicated that the skilled readers performed significantly better than less skilled readers; whilst older readers also outperformed younger readers. The results of Newman-Keuls comparisons among the group means on each task are presented in Table 3.

MATCHING SPEED

Developmental differences were found on most of the name matching tasks. Skilled primary 4 readers were faster than skilled primary 2 readers on all five of the name matching tasks; while less skilled primary 4 readers were faster than less skilled primary 2 readers on all of the five name matching tasks.

Skill differences were also noted: skilled primary 4 readers were faster than less skilled primary 4 readers on 4 of the name matching tasks, while skilled primary 2 readers were faster than less skilled primary 2 readers on 3 of the name matching tasks. Comparison of the means of skilled primary 2 and less skilled primary 4 groups shows a non-significant difference.

Table 4
ANOVA for Reading Comprehension Level

Source	Sum of Squares	df	Mean Squares	F	Significance of F
Total	2579746	79	32655	--	--
Grade	655220	1	655220	212.07	<.001
Skill	1625070	1	1625070	525.96	<.001
Grade X Skill	64639	1	64639	20.92	<.001
Residual	234818	76	3093	--	--

Table 5
ANOVA for High Frequency Character Matching Speed

Source	Sum of Squares	df	Mean Squares	F	Significance of F
Total	7651919	79	96860	--	--
Grade	2795650	1	2795650	65.88	<.001
Skill	1593584	1	1593584	37.55	<.001
Grade X Skill	37628	1	37628	0.89	<.349
Residual	3225057	76	42435	--	--

Table 6
ANOVA FOR Low Frequency Character Matching Speed

Source	Sum of Squares	df	Mean Squares	F	Significance of F
Total	6826706	79	86414	--	--
Grade	1915186	1	1915186	57.54	<.001
Skill	2137926	1	2137926	37.55	<.001
Grade X Skill	243984	1	243984	7.33	<.008
Residual	2529609	76	33284	--	--

Table 7
ANOVA for High Frequency Word Matching Speed

Source	Sum of Squares	df	Mean Squares	F	Significance of F
Total	6387010	79	80848	--	--
Grade	2402631	1	2402631	90.81	<.001
Skill	1779658	1	1779658	67.26	<.001
Grade X Skill	193848	1	193848	7.33	<.008
Residual	2010873	76	26459	--	--

Table 8
ANOVA for Low Frequency Word Matching Speed

Source	Sum of Squares	df	Mean Squares	F	Significance of F
Total	4214876	79	53353	--	--
Grade	1417249	1	1417249	59.60	<.001
Skill	943951	1	943951	39.70	<.001
Grade X Skill	46561	1	46561	1.96	<.166
Residual	1807115	76	23778	--	--

Table 9
ANOVA for Dot Pattern Matching Speed

Source	Sum of Squares	df	Mean Squares	F	Significance of F
Total	2989704	79	37884	--	--
Grade	914850	1	914850	42.70	<.001
Skill	442680	1	442680	20.66	<.001
Grade X Skill	3850	1	3850	0.18	<.673
Residual	1628323	76	37844	--	--

Table 10
ANOVA for Character Vocalization Speed

Source	Sum of Squares	df	Mean Squares	F	Significance of F
Total	5244588	79	66387	--	--
Grade	867570	1	867570	34.74	<.001
Skill	2280488	1	2280488	91.31	<.001
Grade X Skill	198503	1	198503	7.95	<.006
Residual	1898027	76	24974	--	--

Table 11
ANOVA for Character Production Speed

Source	Sum of Squares	df	Mean Squares	F	Significance of F
Total	96429533	79	1220627	--	--
Grade	59897	1	59897	0.05	<.820
Skill	8810618	1	8810618	7.68	<.007
Grade X Skill	340214	1	340214	0.30	<.588
Residual	87218850	76	1147616	--	--

VOCALIZATION SPEED

As indicated in Table 10 and 11, developmental differences were found. In the character vocalization task primary 4 readers were significantly faster than primary 2 readers, [F(1,76)=34.74, p <.001]. However, a non-significant grade level effect was observed in the character production task; no interaction of primary level with skill level was observed in the character production task. Reading skill differences in primary 4 were found for both verbal tasks. Skilled primary 2 readers were also significantly faster than less skilled primary 4 readers on both the character vocalization and production tasks. Non-significant findings were noted in comparing the vocalization speed of less skilled primary 2 and 4 groups. Generally, less skilled readers were slower than skilled readers in character vocalization and delayed character production tasks, [F(1,76) = 91.31, p <.001], and [F(1,76)=7.68, p <.007] respectively. The two-way interaction between primary level and skill level was significant, [F(1,76)=7.95, p <.006]. Differences for the character vocalization and character production speeds between skilled and less skilled reader groups were on the order of 149 msec. and 59 msec. respectively.

Word Length Effect

In order to examine the word length effect a 2 X 2 X 2 (by primary, by skill, and by stimulus type--characters vs. words) factorial analysis of variance was used. The average numbers of strokes for characters and words were 6.8 and 17.1 respectively. To determine the direction of the interactions, Tukey's test on unconfounded means was performed, as displayed in Table 12.

Table 12
Tukey's Test on Unconfounded Means between Characters with less strokes and Words with more strokes:Less skilled vs skilled readers

	SNCLS= 1.406	SNCMS= 1.133	LSNCLS= 1.101	LSNCMS= .875	Critical Value= .061 (p <.05)
SNCLS= 1.406		.273	.305	.531	
SNCMS= 1.133			.032	.258	
LSNCLS= 1.101				.226	
LSNCMS= .875					

Note. SNCLS=Skilled readers naming characters with less strokes; SNCMS=Skilled readers naming characters with more strokes; LSNCLS=Less skilled readers naming characters with less strokes; LSNCMS=Less skilled readers naming words with more strokes. N=40. $p < .05$.

ANOVA calculations on characters and words for different grades and skills are shown in Table 13. The first-order interaction of skill level X word length (as defined by the increase in number of strokes) approached significance, [F(1,76)=3.40, p <.069]. The main ~~ef~~fect of grade level on word length was non-significant (p <.169). The grade X skill X stimulus type interaction was non-significant, [F(1,76)=.02, p <.889]. These results showed the tendency that skilled readers were superior to less skilled readers particularly when the stimuli were characters with fewer strokes. When combined with words with more strokes, skilled readers failed to function at a superior level and processed more or less at the speed of less skilled readers in characters with fewer strokes.

TABLE 13
ANOVA for Word Length Factor (Characters vs. Words)

Source	Sum of Squares	df	Mean Squares	F	Significance of F
Within Cells	980998	76	12908	--	--
Word Length	4982765	1	4982765	386.03	<.001
Grade X Word Length	24869	1	24869	1.93	<.169
Skill X Word Length	43875	1	43875	3.40	<.069
Grade X Skill X Word Length	254	1	254	.02	<.889

Results of the Tukey's test on Table 12 revealed that all readers processed characters (with fewer strokes) significantly faster than two-character words (with more strokes). Skilled readers' naming speed for ~~both~~ characters and words was better than for less skilled readers. No difference was observed when the means of skilled readers in naming words and less skilled readers naming characters were compared. These results indicated that even though the skilled readers were naming more 'lengthy' words, they were processing at more or less the same speed as the less skilled readers in naming simple characters.

Naming latencies are shown in Figure 1 as a function of word length. The direction of the differences seems to suggest that all readers require more time to process increasingly 'lengthy' characters and words. The decoding speeds for skilled primary 2 and less skilled primary 4 readers are more or less the same indicated that even when the latter group were 2 1/2 years older they could not outperform the former. Results of a sign test indicated that significant differences existed between one-character and two-character words, even for skilled primary 4 readers. This group, presumably the most skilled readers represented, showed a difference between high frequency character matching speed and low frequency word matching speed (219 msec.) whereas the less skilled primary 2 readers' difference was 365 msec.

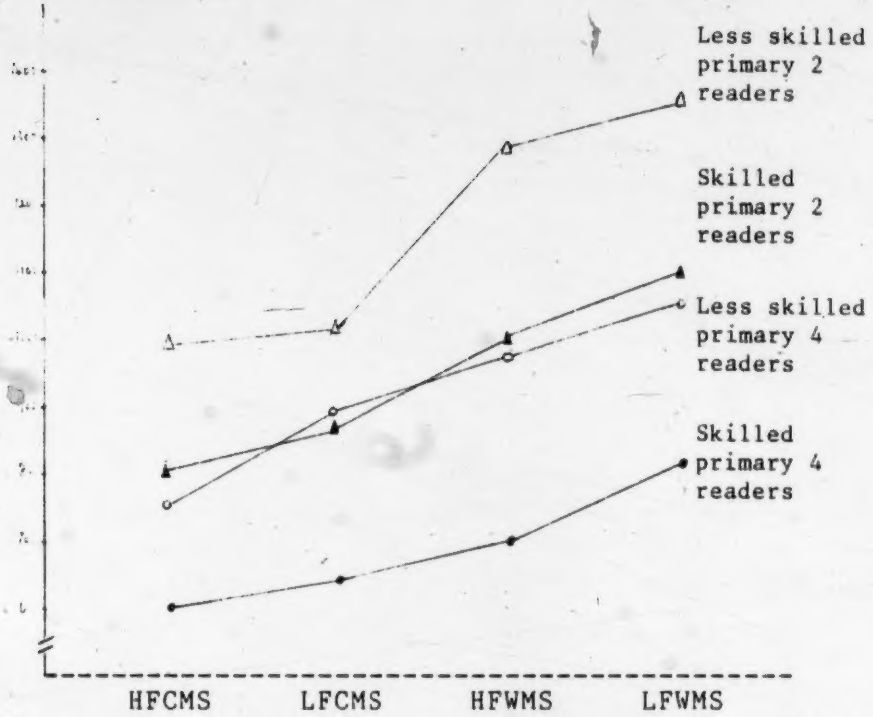


Fig. 1. Mean latencies in msec. for Each Sub-group. Note. HFCMS=High frequency characters matching speed; LFCMS=Low frequency characters matching speed; HFWMS=High frequency words matching speed; LFWMS=Low frequency words matching speed. For each sub-group, n = 20.

Frequency Effect

In order to examine the frequency effect, a 2 X 2 X 2 (by primary level, by skill, by frequency) factorial analysis of variance was employed. To determine the direction of the interactions, Tukey's test on unconfounded means was performed, as displayed in Table 14.

Table 14
Tukey's test on unconfounded means
(by grade, by frequency)

	P4HF= 1.365	P4LF= 1.216	P2HF= 1.004	P2LF= .929	Critical value= .038 (p <.05)
P4HF= 1.365		.148	.360	.436	
P4LF= 1.216			.212	.288	
P2HF= 1.004				.076	
P2LF= .929					

Note. P4HF=Primary 4 readers naming high frequency characters and words; P4LF=Primary 4 readers naming low frequency characters and words; P2HF=Primary 2 readers naming high frequency characters and words; P2LF=Primary 2 readers naming low frequency characters and words. For each group, n = 40.

ANOVA calculations on the effects of the frequency factor on grade level and skill levels are presented on Table 15. The effect of grade level by character and word frequency was significant, [F(1,76)=21.46, p <.001]. A non-significant two-way interaction for skill and frequency was observed, [F(1,76)=1.35, p <.248]. The three-way interaction for grade level, skill and frequency was also non-significant, [F(1,76)=.29, p <.591]. These results indicated an important developmental difference in that older readers responded faster than younger readers in naming high and low frequency characters and words. It is noteworthy that older readers named low frequency characters and words even faster than younger readers in naming commonly known stimuli--high frequency characters and words.

TABLE 15
ANOVA for Frequency Factor (High Frequency Characters and Words vs. Low Frequency Characters and Words)

Source	Sum of Squares	df	Mean Squares	F	Significance of F
Within Cells	379386	76	4886	--	--
Frequency	1002960	1	1002960	205.27	<.001
Grade X Frequency	104871	1	104871	21.56	<.001
Skill X Frequency	6616	1	6616	1.35	<.248
Grade X Skill X Frequency	1424	1	1424	.29	<.591

CORRELATIONAL ANALYSES

In order to study directly the relationship between decoding speed and comprehension, Pearson product-moment correlations were calculated between each subject's median response latency on various tasks and performance on the comprehension tests. The interrelationships among various tasks were also examined. The results of correlational analyses are reported for the following groups: (a) primary 2 and primary 4, (b) less skilled and skilled readers, (c) each sub-group. These correlations are presented in Tables 16, 17, and 18, respectively.

Several patterns are immediately apparent. The relationship between reading comprehension ability and decoding speed changed as a function of age. Although all tasks of the primary 2 readers were significantly correlated with their reading comprehension scores (excluding character production speed, r_s range from .42 to .62), the size of all correlations was smaller than those of the primary 4 readers (excluding character production speed, r_s range from .56 to .82).

Among all tasks, character vocalization speed resulted in the highest correlation with reading comprehension ability in primary 2 and primary 4, $r = .62$ and .82, respectively. The high frequency word matching speed was generally the best predictor of performance on other tasks at primary 2 and primary 4 levels.

Table 16
Correlations Among Tasks for Each Grade

Variable	1	2	3	4	5	6	7	8
Primary 2								
1. RCL		.42**	.48**	.58***	.53***	.48**	.62***	.35*
2. HFCMS			.88***	.80***	.74***	.59***	.70***	.17
3. LFCMS				.89***	.83***	.74***	.67***	.25
4. HFWMS					.90***	.84***	.65***	.25
5. LFWMS						.82***	.70***	.25
6. DMS							.44**	.33*
7. CVS								.30
8. CPS								
Primary 4								
1. RCL		.68***	.74***	.72***	.67 ***	.56 ***	.82***	.36*
2. HFCMS			.88***	.87***	.85 ***	.76 ***	.76***	.46**
3. LFCMS				.89***	.81 ***	.65 ***	.76***	.41**
4. HFWMS					.92 ***	.79 ***	.73***	.48**
5. LFWMS						.84 ***	.70***	.40**
6. DMS							.62***	.52***
7. CVS								.50**
8. CPS								

Note. RCL=Reading Comprehension Level; HFCMS=High frequency characters matching speed; LFCMS=Low frequency characters matching speed; HFWMS=High frequency words matching speed; LFWMS=Low frequency words matching speed; DMS=Dots matching speed; CVS=Characters vocalization speed; CPS=Characters production speed. For primary level, n = 40.

* p <.05   ** p <.01   *** p <.0005

Table 17
Correlations Among Tasks for Reader Groups

Variable	1	2	3	4	5	6	7	8
			Less skilled readers (Primary 2 & 4)					
1. RCL		.56***	.42**	.57***	.56***	.60***	.31*	.00
2. HFCMS			.90***	.90***	.88***	.84***	.50***	-.02
3. LFCMS				.87***	.87***	.79***	.52***	-.04
4. HFWMS					.92***	.87***	.44**	.01
5. LFWMS						.85***	.50**	-.08
6. DMS							.30*	.06
7. CVS								.02
8. CPS								
			Skilled readers (Primary 2 & 4)					
1. RCL		.65***	.66***	.73***	.70***	.64***	.75***	.16
2. HFCMS			.88***	.85***	.81***	.69***	.82***	.25
3. LFCMS				.89***	.81***	.71***	.72***	.27*
4. HFWMS					.93***	.84***	.73***	.28*
5. LFWMS						.87***	.76***	.32*
6. DMS							.69***	.47**
7. CVS								.42**
8. CPS								

Note. RCL=Reading Comprehension Level; HFCMS=High frequency characters matching speed; LFCMS=Low frequency characters matching speed; HFWMS=High frequency words matching speed; LFWMS=Low frequency words matching speed; DMS=Dots matching speed; CVS=Characters vocalization speed; CPS=Characters production speed. For each group, n = 40.

$*p < .05$ $**p < .01$ $***p < .0005$

Comparisons of task interrelationships among skill groups are indicated in Table 16. Less skilled readers tended to be less slower vocalizers relative to their age peers; the relationship of character vocalization skill to reading comprehension level was significant for both groups, r = .31 ($p < .05$) and .75 ($p < .001$).

Differences were also found in the magnitude of the correlations of the name matching tasks with reading comprehension ability. For the skilled readers' group, tasks involving high frequency and low frequency words were most related to differences in reading skill, whereas for less skilled readers, tasks involving high frequency and low frequency characters appeared to be the better predictors.

Results of the correlational analyses of each subgroup are particularly interesting (see Table 18). In the less skilled primary 2 group no name matching measures were significantly related to reading comprehension ability, whereas the skilled primary 2 readers had three name matching measures related to reading comprehension ability, r's from .43 to .51, ($p <.05$). Less skilled primary 4 readers also had three name matching measures significantly related to reading comprehension level, r's from .40 to .45, ($p <.05$); as compared with the skilled primary 4 readers who had only one verbal measure significantly related to reading comprehension level. It is noteworthy that the character vocalization measures for the less skilled primary 2 and 4, and the skilled primary 2 groups were non-significantly correlated to reading comprehension level; only for the most highly skilled group in primary 4 was the character vocalization speed strongly related to reading comprehension, $r = .54$, $p <.001$.

Table 18. Correlations Among Tasks for Each Sub-group

Variable	1	2	3	4	5	6	7	8
Primary 2 (Less skilled readers)								
1. RCL		-.26	-.25	-.05	-.07	.05	.15	.34
2. HFCMS			.87***	.77***	.83***	.72***	.35	-.06
3. LFCMS				.88***	.85***	.74***	.33	-.02
4. HFWMS					.86***	.79***	.26	.03
5. LFWMS						.75***	.53**	.01
6. DMS							.12	.12
7. CVS								.07
8. CPS								
Primary 2 (Skilled readers)								
1. RCL		.03	.31	.43*	.50*	.51*	.14	.39
2. HFCMS			.84***	.70***	.54*	.33	.75***	.19
3. LFCMS				.81***	.69***	.61**	.72***	.42
4. HFWMS					.87***	.81***	.65**	.30
5. LFWMS						.80***	.59**	.34
6. DMS							.35	.47*
7. CVS								.40
8. CPS								
Primary 4 (Less skilled readers)								
1. RCL		.41*	.40*	.28	.35	.45*	.01	-.16
2. HFCMS			.88***	.84***	.73***	.72***	.44*	.20
3. LFCMS				.72***	.77***	.62**	.59**	.06
4. HFWMS					.83***	.78***	.34	.20
5. LFWMS						.74**	.21	-.08
6. DMS							.11	.19
7. CVS								.04
8. CPS								
Primary 4 (Skilled readers)								
1. RCL		.16	-.16	-.03	.18	.27	.54**	.25
2. HFCMS			.74***	.73***	.75***	.65**	.58**	.41
3. LFCMS				.74***	.60**	.44*	.25	.31
4. HFWMS					.88***	.73***	.32	.45*
5. LFWMS						.81***	.53**	.45*
6. DMS							.60**	.60**
7. CVS								.65**
8. CPS								

Note. RCL=Reading Comprehension Level; HFCMS=High frequency characters matching speed; LFCMS=Low frequency characters matching speed; HFWMS=High frequency words matching speed; LFWMS=Low frequency words matching speed; DMS=Dots matching speed; CVS=Characters vocalization speed; CPS=Characters production speed. For each sub-group, n = 20. * p <.05 ** p <.01 ***p <.0005

Multiple Regression Analyses

Stepwise multiple regression analyses were calculated to find those tasks that accounted for the most variance in the reading comprehension level. Three analyses were conducted (one for each primary level), followed by further two analyses (one for each skill group and one for each sub-group). All variables mentioned earlier were included, and at each step in the analysis, the variable that accounted for the most residual variance was entered into the regression equation. Stepwise inclusion continued until the improvement in the regression sum of squares at a given step became non-significant at the .05 level.

Primary 2. For the primary 2 readers, character vocalization speed was the first variable entered into the equation, accounting for 40% of the variance in reading comprehension ability, [$F(1,38)=24.76$, $p < .001$]. After this first step, none of the remaining variables made a significant improvement in prediction. A commonality analysis was calculated on the regression sum of squares to determine the unique contribution made by character vocalization. Unique contribution was defined in terms of the change in R^2 that resulted when a variable or set of variables was entered last in the regression equation. The results of this analysis are shown in

Table 19. All 7 variables accounted for 53% of the variance in reading comprehension performance, 13% of which was uniquely due to character vocalization speed. When the remaining 6 variables were entered together after character vocalization, they uniquely accounted for only 13% of the variance. It seems that character vocalization was the only variable to contribute because it was the best predictor.

Primary 4. Regression analysis on the primary 4 group indicated that character vocalization speed was the first variable entered into the equation, accounting for 67% of the variance in reading comprehension scores, [F(1,38)=77.54, p <.001]. After this step, none of the remaining variables made a significant improvement in prediction. Together all 7 variables accounted for 72% of the variance in reading comprehension ability. The results of commonality analysis at the primary 4 level are shown in Table 19. Character vocalization speed made a unique contribution to the explained variance (15%), whereas the unique contributions of all other variables were much smaller, at only 5%.

Table 19
Commonality Analyses at Each Primary Level

Variable	Variance %	β weight
Primary 2		
Unique to character vocalization	13	.63
Unique to other variables	13	
Common to all variables	27	
R^2	53	
Primary 4		
Unique to character vocalization	15	.82
Unique to other variables	5	
Common to all variables	52	
R^2	72	

Less skilled readers. For the less skilled primary 2 and 4 readers, only one variable was entered before non-significant improvement was reached. Dots matching speed accounted for 36% of the variance in reading comprehension level, [$F(1,38)=21.00$, $p <.001$]. The partition of the regression sum of squares into its common and unique contributions is shown in Table 20.

Together all 7 variables accounted for 46% of the variance in the reading comprehension skill. The unique contribution of dots matching speed comprised only 4% of the variance in reading comprehension level, whereas the unique contributions of other variables accounted for 10%. A very large proportion of the explained variance

(32%) was due to the commonality among all variables rather than to any unique contributions. Thus, even though dots matching speed was highly correlated with reading comprehension level in the less skilled readers, the unique contribution to the variance as accounted for by this variable was rather small.

Table 20
Commonality Analyses Among Reading Groups

Variable	Variance (%)	β weight
Less skilled readers (primary 2 & primary 4)		
Unique to dots matching speed	4	.60
Unique to other variables	10	
Common to all variables	32	
R^2	46	
Skilled readers (primary 2 & primary 4)		
Unique to character vocalization speed	9	.47
Unique to high frequency word matching speed	7	.39
Unique to other variables	7	
Common to all variables	47	
R^2	70	

Skilled readers. In the regression analysis of the primary 2 and 4 skilled readers, 2 variables entered the equation: (a) character vocalization speed, (b) high frequency word matching speed. Together these variables accounted for 63% of the variance in reading comprehension level, [F(2,37)=31.48, p <.001]. The unique and common contributions of these variables are shown in Table 20. The character vocalization speed and high frequency word matching speed made unique contributions to the variance, 9% and 7% respectively, whereas over 47% of the explained variance was due to the commonality among all the variables.

Sub-group. The regression analyses of each sub-group are particularly interesting and are displayed in Table 21. Results revealed that no single variable, either uniquely or commonly with other variables, significantly accounted for the variance in reading comprehension level in the less skilled primary 2 group. The unique contribution of dots pattern matching speed accounted for 5 and 7 % of variance in reading comprehension level in the skilled primary 2 and less skilled primary 4 groups. Thus, the latter being two years older than the former were more or less still using the same decoding skills; whilst character vocalization speed uniquely accounted for 8% of the variance in reading comprehension level in the skilled primary 4 readers group indicating this group was using fluent verbal skills.

Table 21
Commonality Analyses among Each sub-group

Variance	Variance (%)	β weight
Less skilled primary 2 readers		
R^2	44	
Skilled primary 2 readers		
Unique to dots matching speed	5	.51
Unique to other variables	24	
Common to all variables	21	
R^2	50	
Less skilled primary 4 readers		
Unique to dots matching speed	7	.45
Unique to other variables	16	
Common to all variables	14	
R^2	37	
Skilled primary 4 readers		
Unique to character vocalization speed	8	.54
Unique to other variables	11	
Common to all variables	21	
R^2	40	

CHAPTER VI

DISCUSSION

LaBerge and Samuels' (1974) model of reading was offered as an explanation for the failure of comprehension. Using the limited capacity model of working memory, LaBerge and Samuels postulated that the faster and more automatic is word processing, the more the space in memory is available for the execution of higher level processing such as comprehension. The relationship between decoding and comprehension is central to LeBerge and Samuels' model of automaticity in reading. Slow decoding would consume a lot of attentional resources, and since decoding and comprehension share the limited attention capacity, comprehension would be adversely affected. Repeatedly, research employing English speaking subjects has shown that skilled readers can recognise words faster than less skilled readers. On the other hand, it is a well known fact that the linguistic properties of Chinese and English languages are different. Would the model of automaticity in reading still apply if the stimuli were Chinese? The purpose of this thesis was to examine the model of automaticity in reading particularly in explaining the relationship between decoding skill and comprehension ability among skilled and less skilled Chinese primary school readers.

In light of the notion of automaticity in reading, the following hypotheses were offered for examination:

1. With similar chronological age, skilled readers have faster decoding speed than less skilled comprehenders.
2. Two-character words with more strokes require more time to decode than single characters with fewer strokes.
3. Low frequency characters and words require more time to decode than high frequency characters and words.
4. Decoding speed increases as a function of age.
5. Factors predicting reading comprehension ability are different for skilled and less skilled readers.

Hypothesis 1. With similar chronological age, skilled readers have faster decoding speed than less skilled comprehenders.

The fact that skilled and less skilled Chinese readers displayed large differences on character and word naming time confirmed hypothesis one: skilled readers have faster decoding speed than less skilled age-peer readers. This is consistent with earlier research showing word level factors to have strong relationships with reading skill (Biemiller, 1977/78; Perfetti & Hogaboam, 1975; Stanovich, 1980). Another noteworthy point was that the less skilled primary 4 readers have more or less the same decoding speed as the skilled primary 2 readers on all tasks involving graphemic coding processing. This shows that although the former group was 2 years older than the latter, they could not outperform the skilled younger readers. The present study is particularly indicative of this relationship, since very large differences were obtained with groups of skilled and less skilled readers whose median scores were calculated in order to avoid markedly skewed distributions (thus serving as a better measure of central tendency). Trials on which subjects named the wrong characters were eliminated. As a result of all these procedures, the median vocalization times of the skilled readers were based on a larger set of characters than those of the less skilled readers. The skilled primary 2 readers showed a 262 msec. and skilled primary 4 readers showed a 267 msec. advantage over their same-age group peers in high frequency words matching speed even though they were naming words that were more difficult than those on which the reaction times of the less skilled counterparts were based.

It is important to note that skilled readers were significantly faster than less skilled age-peer readers on all tasks involving both the graphemic coding and phonological coding processing. It is likely that their slowness in decoding, or the lack of automatic processing in reading, may impede comprehension. The importance of automaticity of reading has been pointed out by LaBerge and Samuels (1974) whereby a reader is considered to have to strike a balance between attention to decoding and comprehension. Excessive attention to decoding would impede comprehension. Thus, a reader has to switch attention back and forth from decoding to comprehension. Essentially, fast decoding would aid comprehension. During reading, comprehension involves sharing some limited capacity system--the working memory--among various task components. This same limited capacity processor has to be used to remember words already read and to think about the meaning of what is read. Hence, as decoding becomes faster, the resource required to monitor and maintain decoding decreases--allowing more effort to be directed toward understanding what is being read.

Some of the potential sources of failure in developing rapid, automatic decoding ability can be identified. One possible explanation is that less skilled readers have had less practice at identifying Chinese characters and words, resulting in a slower buildup of automatic word recognition skills. However, results of two previous studies suggest that this is probably not the primary source of reading comprehension difficulty in the less skilled readers. Perfetti and Hogaboam (1975) required less skilled and skilled readers to perform a word naming task. Skilled readers were found to be faster at naming high frequency and nonsense words. Another study by Hogaboam and Perfetti (1978) revealed that even after a considerable amount of practice, less skilled readers were still significantly slower in name matching tasks. Perfetti and Hogaboam (1975) suggested that the reason for the persistence of difficulties among less skilled readers was not due to a simple lack of exposure to printed words but to a failure in developing rapid automatic word recognition: a deficit in decoding.

The way in which decoding skills affect reading comprehension performance is not exactly clear. On the theoretical level, it may be that less skilled readers do not read the words quickly enough to be able to put them into large thought units. On the empirical level, there is also evidence supporting this proposition. Based on the speed and decoding errors of oral reading, Clay and Imlach (1971) divided subjects into four groups from low to high. Factors like the length of pauses were studied. When the tapes of the readings were analyzed, the best decoders paused briefly at punctuation and read, on the average, 7.4 words between pauses, whereas the poor decoders read only 1.3 words between pauses. The poor decoders were reading continuous passage as though they were lists of unrelated words. The skilled decoders seemed to read in "syntactic chunks" rather than a word-by-word basis. These results tend to suggest that poor decoding skills hamper the process whereby the reader chunks text into units larger than the single word.

Could it be that skilled and less skilled readers differ only in production skills and not in decoding skills? The aspect of production was taken care of experimentally in the character production task in which the character is presented to the subject for 3 seconds, sufficient to ensure decoding but in which a response is not made until a red dot appeared. The mean character production speed among various groups when compared indicated no significant developmental difference but showed significant skill difference: skilled readers had faster vocal character production speed than less skilled readers in their respective grade level. Nonetheless, Seymour and Porpodas (1980) tested dyslexic subjects and found that they were slow in word naming, but they named pictures of objects as fast as non-dyslexic subjects. Such findings demonstrated that a production skill deficit is not a characteristic of less skilled readers.

Reader ability differences on the delayed character production task were on the order of 59 msec., whereas corresponding differences on the name matching tasks were approximately 225 msec. Since skilled readers know more words than less skilled readers, they are more familiar with the words; the decoding speed difference may be regarded as a consequence of the "knowledge" or "familiarity" difference. This hypothesis is apparently not valid when one examines the results of the dots pattern matching speed. The poor decoding skill of the less skilled readers is even more pronounced in dots matching tasks in which meaningless patterns were the stimuli. Of course, more knowledge at the word level would not facilitate processing of meaningless symbols. The lexical decision of a dot patterns matching task must be accessed via a graphemic processing strategy since phonological coding will not work for them. Thus, if the differences of achievement in the comprehension of text are due to phonological deficit only, then skilled and less skilled readers should not differ in a graphemic processing task such as a dot pattern matching task, which involves no semantic cues. The fact that skilled readers were significantly faster than less skilled readers on the dot pattern matching task indicated that less skilled readers might experience difficulties at graphemic processing level. Therefore, based on the results of this study a general process of retrieval and coding deficit appears to be a characteristic of the less skilled readers (Perfetti & Hogaboam, 1975; Vellutino, 1979). The present results are consistent with the studies of Denckla and Rudel (1976), and Spring and Capps (1975) who found that dyslexic children named objects, colors, and pictures slower than nondyslexic children.

Could it be possible that skilled and less skilled readers differ in visual processing skill and not in decoding skills? After reviewing a considerable amount of research on visual processing of skilled and less skilled readers, Stanovich (1982) concluded that "either good or poor readers do not differ in basic visual information processing skills or, if such a relationship does exist, it accounts for only a very small proportion of the variance in reading ability" (p. 487). It appears that there is no visual processing difference between skilled and less skilled readers. Bouma and Legein (1980) argued that the deficits shown by less skilled readers in tachistoscopic tasks are not due to problems in visual processing but to slower speech recoding on the part of the less skilled readers.

It is reasonable to conclude that some differences in reading comprehension performance emerge because of differences in basic skills such as decoding. It is evident that less skilled readers have less well developed and less automatic decoding skill as indicated in the slowness in name matching and vocalization measures. If the decoding skills are less automatic, they may require more attention and would thus require more of the limited capacity needed for higher order processes of comprehension.

Hypothesis 2. Two-character words with more strokes require more time to decode than single characters with fewer strokes.

An important finding was that younger and less skilled readers showed considerably larger effects of word length than older and skilled readers. This confirmed the second hypothesis. One possible explanation for this result is that less skilled readers tend to process Chinese characters and words in smaller configurations than skilled readers and hence are more affected by increases in the number of strokes in the word. This is consistent with the results in studies examining Chinese subjects (Ai, 1955) and English subjects (Juloa et al., 1978; Samuels, LaBerge & Bremer, 1978; McCormick & Samuels, 1979). Ai (1955) showed that characters with less than 10 strokes were recognized better after short exposure than characters with high stroke number. The findings of McCormick & Samuels (1979) and others also indicated that younger and less skilled readers take longer to process longer words.

The word length effect of the present study also reconfirms the findings of Eriksen, Pollack and Montague (1970) who found that the number of syllables is positively related to the reaction time. In Chinese, there is a one-to-one correspondence in character-syllable relationship. Thus, the fact that readers need relatively more time to process two-character words than single character words seems reasonable. The present word length effect is also consistent with Hogaboam and Perfettis' (1978) research showing that less skilled readers required significantly more time to process as the number of syllables incr~~eased than~~ did skilled readers.

In regard to the unit of processing issue, it was expected the older and skilled readers would show a non-significant increase in latency across one-character and two-character words. Results indicated that significant differences existed between one-character and two-character words, even for skilled primary 4 readers. Being the most linguistically skilled group, the fact that even they have to spend increasingly more time as the tasks become more complex is unexpected. If this group was processing characters and words holistically, there should not be significant differences in the latency measures. However, one has to be cautious in inferring that the significant differences of skilled readers across tasks is the consequence of processing information on a component-by-component basis. In fact, the significant increase of latencies seems to be due to the extreme stroke difference between the characters and words (6.8 strokes vs. 17.6 strokes). With such a large discrepancy, differences in processing time are not unreasonable.

Hypothesis 3. Low frequency characters and words require more time to decode than high frequency characters and words.

Results from the present study demonstrated that high frequency characters and words were responded to faster than low frequency characters and words. These findings are consistent with the research of Rubenstein, Garfield and Millikan (1970) who found similar results. There are two possible explanations to this word frequency effect. One explanation was offered by McCusker, Hillinger and Bias (1981) who presented a dual access model of reading. One pathway is phonological and requires a process of grapheme-phoneme conversion--speech recoding. The other pathway is a visual route that is some sort of internal visual representation mediating between a word's printed form and its semantic representation. It is assumed that the visual and phonological pathways in most cases proceed in parallel but the former usually reaches the lexical entry much faster than the latter. The model assumes the existence of a pool of high frequency words that may be accessed rapidly via a visual representation; all other words, having no such visual representation, would by default be accessed by the slower phonological recoding procedure. In this model, the phonological pathway may be important for the less skilled readers, but the increases in reading speed by the skilled readers may reflect a "bypass" of phonological recoding in favor of visually mediated access.

Another possible explanation of the word frequency effect was suggested by Balota and Chumbley (1984) who argued that words differ on a familiarity/meaningfulness dimension. The reader may actually need to check the configuration of the character against the configuration of the character contained in the reader's lexicon. This extra analysis requires additional times; thus longer latencies will be found for those low frequency characters and words requiring such analysis. Low frequency words have lower values on the familiarity/meaningfulness dimension than high frequency words. Thus the global analysis of a low frequency word will less often result in a familiarity/meaningfulness value that exceeds the high criterion and permits a rapid word response. In future, more research is needed to justify what exactly has accounted for the word frequency effect.

Hypothesis 4. Decoding speed increases as a function of age.

Results from the reaction time tasks tend to support this hypothesis. Developmental improvement in reading appears to be attributable to the increase in general capacity to identify characters and words rapidly. Between primary 2 and primary 4, time on the high frequency character naming task is reduced by 220 msec. (from 890 msec. to 670 msec.). This would reflect the improvement in general decoding speed. The dots matching task also provides evidence supporting the developmental aspect of the increase in decoding ability; time on the dots matching tasks is reduced by 344 msec. (from 1,449 to 1,105 msec.).

The significant developmental difference among the high frequency, and low frequency word speeds is an important result from the standpoint of vocabulary. The difference between primary 4 and 2 readers cannot be said to be due to vocabulary differences. For one thing, the high frequency words data analyses were only for words whose meaning was known to the readers. Furthermore, the significant developmental difference between groups was found for dots matching which was meaningless for all readers and certainly would not be affected by the vocabulary knowledge of an individual. These results seem to support the view that development of reading skills consists of development of efficient decoding speed.

There seems to be an underlying ability to verbally identify print items quickly. This ability improves with age between primary 2 and 4. There is an additional ability to verbally identify printed Chinese characters and words rapidly. Presumably older and skilled readers use orthographic information to reduce the number of distictive features (Smith, 1971; Gibson & Levin, 1975), however, such theoretical speculation has still to be validated empirically. In any case, such ability also improves with age.

Hypothesis 5. Factors predicting reading comprehension ability are different for skilled and less skilled readers.

Based on the regression analyses, dots matching speed is a significant predictor of reading comprehension performance among less skilled readers, whereas character vocalization speed and high frequency words matching speed are singificant predictors of reading comprehension level among skilled readers, accounting for 63% of the variance of the reading comprehension measures. The contribution of character vocalization ability to reading comprehension variance among the less skilled readers was due to its commonality with the decoding measures rather than to its uniqueness.

Such findings tend to suggest that less skilled readers rely more on graphemic coding in terms of their cognitive development. On the other hand, skilled readers have mastered both graphemic and phonological coding skills, hence did not solely rely on graphemic skills. When they were required to decode certain stimuli, they tended to relate to the verbal coding process.

CHAPTER VII

CONCLUSION : IMPLICATIONS AND LIMITATIONS

The notion of automaticity has long been used to describe the attainment of a high level of competence (Henderson, 1982). LaBerge and Samuels (1974) used the term automaticity in the explanation of the reading process. They postulated that reading involved two stages: decoding and comprehension. When decoding is taking up too many attentional resources, then it is difficult for comprehension to occur due to the simple fact that there is not enough attention exerted for the comprehension purpose. Hence, less skilled readers are likely to encounter reading comprehension difficulties when they concentrate too heavily on decoding of words. On the other hand, skilled readers have faster word decoding speed, therefore more attention can be directed to higher level comprehension processing.

Researchers (Biemiller, 1977/78; Curtis, 1980; Lesgold & Resnick, 1982; Perfetti & Hogaboam, 1975; Sternberg & Wagner, 1980) had generally supported LaBerge and Samuels' (1974) model of automaticity in reading. The concensus was that because of the failure to achieve automaticity in word processing, as indicated in the slowness in decoding words, less skilled readers tend to experience difficulties in comprehending passages. This argument is also supported by researchers employing a different technique--the Stroop interference test (1935). Researchers (Ehri, 1977; Golinkoff & Rosinski, 1976; Guttentag & Haith, 1978; Rosinski, 1977) demonstrated that skilled readers tend to experience more interference in the Stroop task than less skilled readers. This result is interpreted as evidence supporting the notion of automaticity in reading because skilled readers could not refrain from ignoring printed words.

It is interesting to note that most, if not all, of the research on the automaticity of reading was carried out in the English language. The information processing of the Chinese language is a relatively unexplored area. Chinese orthography has often been erroneously considered as pictorial, arbitrary and non-phonological. Even psychologists were led to conceive that reading disability does not exist when people are required to process sign scripts. In fact, more appropriate research (e.g. Steveson, et al. 1982) and the present research indirectly help to clarify that reading disability also prevails in the Chinese language.

The major finding of the present research is that skilled Chinese readers have faster decoding speed than less skilled age-peer readers. This result is consistent with the research with English-speaking subjects (e.g. Curtis, 1982; Perfetti & Hogaboam, 1975). It also helps to further explain and support the notion of automaticity in reading. Together with other research findings indicating that less skilled readers do not have a visual processing deficit, at this stage it is reasonable to conclude that the less skilled Chinese readers, like their English counterparts, tend to experience a general retrieval and coding deficit. During reading, this slow decoding may require more attention and would thus require more of the limited capacity needed for higher order processes of comprehension.

Another important finding is that decoding speed increases as a function of age: the older readers have significantly faster decoding speed than younger readers. This processing difference was even more prominent when subjects were required to respond to meaningless dot patterns. This difference in decoding speed would certainly not be affected by the vocabulary knowledge of the older readers.

The present word length effect is consistent with research with English subjects (e.g. Juola et al. 1978). Two-character words (presumably having more strokes) required more time to decode than single characters (with fewer strokes). In modern Chinese (but not in Taiwan) many frequently used characters have been simplified--reducing the number of strokes from an average of sixteen to eight per character (Liu, 1978). For instance, the character 酒 (chau), "wine" in its original form was transformed into 氿, the 氵 "water radical" was retained giving the meaning for being liquid, but another character 九 (gkáu) was borrowed as the phonetic part to form the simplified character saving a number of strokes. The fact that two-character words with more strokes required more time to process than single characters with fewer strokes should not be interpreted as a defense of the simplified script. The word length effect of the present research should have no direct bearing on the language reform movement because the Chinese characters and words were taken from a body of complex characters. In addition, all subjects learned only complex characters 繁體字 rather than simplified characters 簡體字 . It would be interesting to look into how readers of simplified characters may differ in terms of their cognitive processing.

The present study also revealed the word frequency effect: high frequency Chinese characters and words were decoded faster than low frequency characters and words.

This result reconfirmed the finding of Ruberstein, Garfield and Millikan (1970). It is likely that readers responded to the high frequency stimuli faster because of the simple fact that they have seen them more often than other stimuli so the readers are more familiar with them.

In terms of the prediction of reading comprehension performance, pattern matching ability seems to be reliable predictor for less skilled readers, whilst vocalization speed and high frequency words matching speed tend to be the significant predictors for skilled readers. These results indicated that the processing of the skilled and less skilled readers may be different. The former is likely to have mastered graphemic and phonological processing, whereas the latter group may still be functioning at the graphemic level.

IMPLICATIONS

An important implication, derived directly from the experiments in this study, is taken from the work on automatic decoding. If naming and vocalization latencies are regarded as indicators of the automaticity of a reading process (LaBerge & Samuels, 1974), then an implication of more rapid decoding is that the skilled readers are probably getting the decoding done with less load on attention. When decoding can be accomplished with no attention, attention can then be available for purposes of comprehension. The role of rapid decoding speed in fluent reading is apparent, even when one is processing information in Chinese. The way a skilled Chinese reader recognizes characters is influenced by total configuration; likewise the way a skilled English reader recognizes words is dependent not so much on the recognition of individual letters but on the recognition of the whole word. Thus, the ways of learning the reading of an alphabetic system may not be very different from those of a logographic script such as Chinese (Carroll, 1972).

The role of practice to the point of automaticity should be stressed. With less skilled readers, the way to better reading is by reading. As the saying goes "practice makes perfect". It is likely that less skilled readers do not have adequate practice in verbal encoding and decoding. The mastery of component subskills of reading to automaticity has been repeatedly emphasized by different researchers (Guthrie, 1977; LaBerge & Samuels, 1974). Overlearning is practice beyond the point of mastery and this will likely free readers from attention to certain subskills so that they can attend to other component subskills. From the instruction point of view, Samuels (1979) suggested the supplementary method of repeated reading as a means of improving students' reading speed and comprehension. Students can work toward a better performance through rereading a specific and meaningful passage a number of times until a certain criterion level of fluency is reached before attempting a new passage in a similar manner. Such practice, as Samuels (1979) argued, if given enough opportunities would lead to automaticity.

An implication suggested by the present findings is that teachers should be aware that decoding skills develop beyond accuracy and the speed of decoding is related to comprehension. There is a need to conceive of and teach decoding and comprehension, not as separate subskills, but as conceptual systems related to each other. It is indeed not surprising to see that the training of accurate, rapid decoding of isolated words in English studies (Bengston & Smith, 1983; Fleisher, Jenkins, & Pang, 1979) and in Chinese studies (Chan & Cheng, 1976) fails to improve reading comprehension ability. The inadequacy of such an approach is apparent: reading becomes difficult and inefficient because children are encouraged to deal with each word as if it stood in isolation. As a consequence, even word identification suffers. Training in making both speeded and tachistoscopic identifications distorts the nature of the reading process, inaccurately implying that precise identification of all the words is necessary for obtaining meaning. As a result, children tend to assume that reading means simply identifying words. The supposed means to comprehension becomes an end in itself.

The present findings also indicate that it is desirable to pay more attention to the small amount of actual reading practice that less skilled readers receive. There seems to be a potential vicious circle in which initial slow reading may lead to reduced opportunities for practice which in turn reduces opportunities both for extracting intraword structure and possibly for increasing general decoding speed. Since less skilled readers can generally use context to facilitate speed, thus practice for such readers should emphasize actual reading rather than extracting meaning from a passage.

LIMITATIONS OF THE STUDY

It is evident that the information processing of an item in a tachistoscopic identification task may be quite different from the type of psycholinguistic processing that occurs during comprehension of normal passages. Decoding flashed characters, presented singly or in pairs, is not an exact duplication of real life reading. It is important to note that identifying an isolated character or word rapidly does not necessarily result in obtaining the meaning. An interesting case is that skilled readers read for meaning rather than for the precise identification of all the words. Obtaining the meaning is usually possible without identifying all the characters and words.

It is possible that the limitation of the discrete-trial procedure is to some extent corrected by a continuous naming paradigm. The differences in the degree of automatization of certain classes of stimuli may be revealed only on continuous naming tasks that, like reading, do require more than retrieval of a single name (Blackman, 1984; Stanovich, 1981). Another weakness in terms of the methodology of the present study is the problem of using naming and vocalization latencies as measures of decoding. Vocalizing is certainly an unnatural act during skilled reading.

In the present study, stimuli were chosen on the basis of frequency only. Frequency counts do have limitations. There are other factors such as general configuration, stroke sequence, symmetry, number of substructures, visual confusability of graphemes with similar characters, acoustic confusabiltiy of homophones, and meaningfulness that help or impede the recognition of characters. In future, in carrying out research in the information processing of the Chinese language, it is important to select characters on the basis of not only frequency but also other orthograpic dimensions (Leong, 1977; 1984).

Another methodological limitation was the obvious speed-accuracy trade-off in reaction time analyses. There is an inverse relationship between the speed and accuracy of performance. When one tries to do something very fast, one tends to make more errors than if he does so slowly. This has important implications for the present study since reaction time was chosen to be the dependent variable. Though the error rate of different sub-groups was observed to be non-significant, in future, it is desirable to jointly consider speed and accuracy as dependent variables--after all reaction time depends in part upon the error rate.

Another weakness was evident in the statistical analyses of the research data. When the independent variables are correlated among themselves (e.g. the correlation between HFWMS and LFWMS for skilled primary 2 and 4 readers was .93 in Table 17), the unique contribution of each on reading comprehension performance is difficult to assess. It is, however, likely that large intercorrelations between the independent variables can substantially affect the results of multiple regression analysis.

The notion of automaticity has stirred up some criticism as an explanatory concept (Allport, 1980; Cheng, 1985; Henderson, 1982; Ryan, 1983). Whenever two tasks can be performed simultaneously, one convenient explanation is that: both must be competing for limited, general-purpose capacity. Alternatively, one or both of the tasks does not require attention; it must be automatic. The sad fact is that the story will always appear to fit. To say that an action has become automatic does not explain what has happened. It would also divert the attention from a very interesting phenomenon: What are the multiple mechanisms or strategies that are competing in different task combinations?

The concept of automaticity also has difficulty especially in explaning complex processes such as reading (Cheng, 1985). Certainly, if one knows every word in a passage and can read it rapidly and acccurately, one still ~~may have di~~fficulty in comprehending the meaning. An interesting example is in reading a legal document. While accuracy and speed of decoding are important for comprehension, they may not be enough to guarantee adequate understanding. Clinical observations have presented evidence that some children may read aloud quite readily without understanding what they read (Guthrie, 1977). There is also experimental support for the notion that accuracy and speed do not guarantee comprehension. Anderson, Goldberg, and Hidde (1971) required adults to read sentences aloud. Some subjects had to fill in blanks at the end of sentences; others had not. The assumption was that filling in a blank such as "a circle has neither ( ) nor an end" requires some understanding of the sentence. Subjects were required to say the last word of the sentences when they were given the subject noun in the sentence. Subjects who filled in blanks recalled the sentences significantly better than those who did not. This finding indicated that when subjects are required to attend to the meaning of a sentence, understanding and recall are facilitated. Even though everyone was fast and accurate in decoding, the influence of attention on processing and memory occurred. It is important to realize the effect of employing efficient strategies in a reading task.

It seems that at present research can only demonstrate a strong correlational relationship between decoding speed and comprehension. In order to explore the possible causal relationship, in future researchers may choose to train both skilled and less skilled readers to facilitate word decoding rapidly within and without context. More well controlled studies can undoubtedly help to clarify the issue. It is only by training readers in using more efficient and sophisticated decoding strategies that one can examine decoding at the word level and reading comprehension more closely. With the exception of the study by Lesgold and Resnick (1982), longitudinal research in this area is scarce. Perhaps, in future more studies should adopt this approach.

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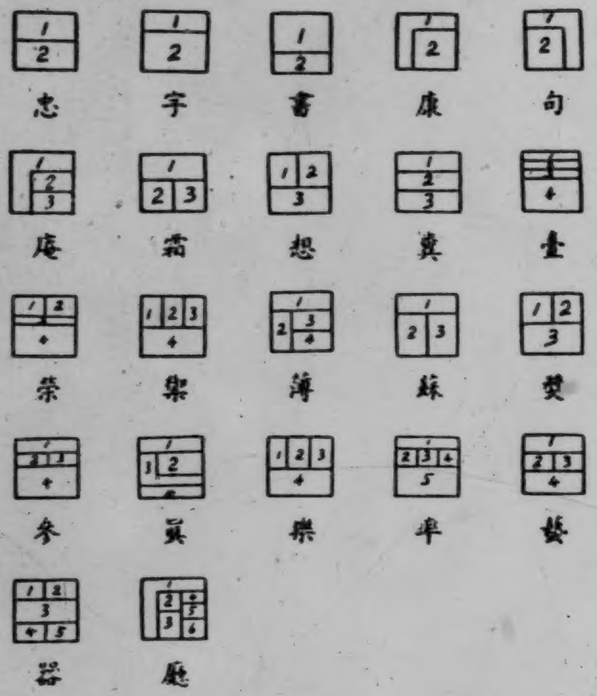
APPENDIX A

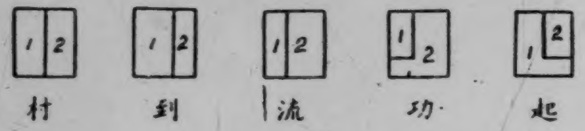
DIFFERENT COMBINATIONS OF CHARACTER STRUCTURES

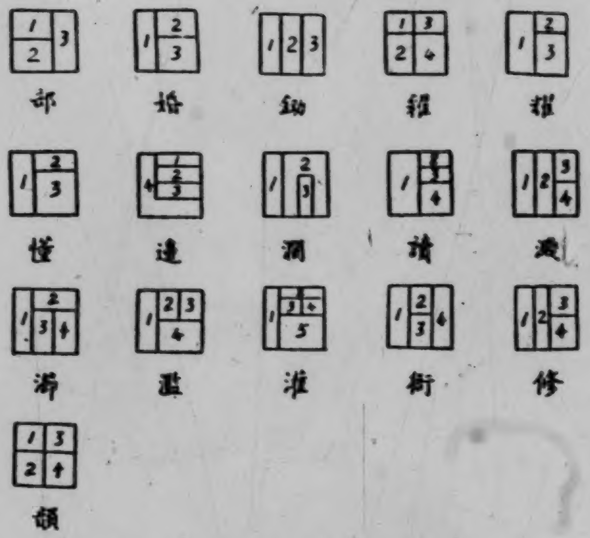
Appendix A: Different Combinations of Character Structures

1. Upper-lower combinations:

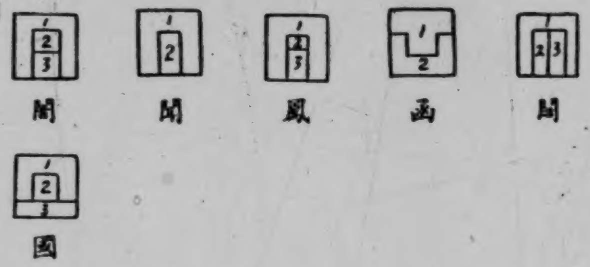

忠 宇 書 康 句
庵 霜 想 莫 壹
崇 梁 薄 蘇 贊
參 冀 樂 率 婺
器 廳

2. Left-right combinations:




部 拾 鋤 緝 描
慢 遣 潤 讀 瀨
滿 監 灌 街 修
頡

3. Inner-outer combinations:



APPENDIX B

INFORMAL CHINESE ORAL READING COMPREHENSION TEST

Appendix B: Informal Chinese Oral Reading Comprehension Test -Level one and Level two

一

我家的門前，有一條小河。我常常到河邊去釣魚。我家的後面，有一個小山。我常常到山上去遊玩。

二

我放學回家，見了爸媽，我說：「我回來了。」吃過飯，做功課。今天的功課，今天就做好。有空時，我做家務，弟弟和妹妹一起玩。

Level three and Level four

三

星期日，爸爸帶我們到遊樂場去。遊樂場裏玩具多。弟弟騎木馬，木馬跑得快。哥哥坐飛機。

姐姐坐火車，穿過山洞在軌道上跑。我乘小汽船，在水面上來來去去眞有趣。

四

屋子裏沒有貓兒的叫聲，老鼠心裏高興極了。後來，牠在厨房裏找到[illegible]塊肉。牠說：「好香的肉呀！」正要把肉偷走的時候，忽然「的得」一聲，牠便被困在籠子裏去了。

Level five and Level six

五

很多花鹿·在山林中生活。早晨·牠們跑出樹林外呼吸新鮮空氣·又跑到水邊去洗臉。大鹿跑上山坡找食物。小鹿跑到最高的地方·看大海的景色。牠們的生活·過得很快樂。

六

黃道周小時候就極聰明·五歲進小學讀書。七歲·他父親講歷史故事給他聽·他便分出那個是好人·那個是壞人。

他常常喜歡獨自一人帶著書跑到山頂·他讀書興趣很高。他是明朝的大學問家。

七

相傳天后娘娘是生辰在漁村的，她跟人學過觀察天氣和替人醫病，所以她會告訴村民，什麼日子可以出海捕魚，什麼時候會有大風浪。村民都得到平安；村民有病，她又會採摘草藥替他們醫病。

八

晚上，收音機播放故事，秀娟聽得着了迷。這是一個恐怖的故事，秀娟聽得心裏砰砰的跳。故事講完後，媽媽對秀娟說：「夜了，快睡覺吧。」媽媽替秀娟蓋上被，並且替她把電燈熄了。她望著窗外，總是睡不著。

Level nine and Level ten

九

哥白尼做醫生看病是不收費的·當時很多貧苦病人·都受到他的恩惠。他雖然是一個牧師·但他醫治病人的方法非常科學化·從來不像其他牧師一樣·祇靠祈禱。他在業餘時間·仍然繼續研究天文學。

十

象在動物中是最文靜的·但若遭到侵犯·那就會惹起無比的憤怒·牠的視覺遲鈍·但聽覺敏銳。象的重要食物是樹葉和樹枝。牠對於水是很重要的。每年三月至五月是小象出世的時期。

Level eleven and Level twelve

十一

到過桂林的人，都知道那裏的山水有獨特的風格，它顯著的特點是：沿江的山往往奇峯突起，傲然獨立，形狀好像寶塔或玉筍；山上沒有很厚的泥土，只有亂草雜樹，有些簡直是光滑的岩壁。

十二

勤勞的建築家——蟋蟀，有固定的家庭，這是牠工作的報酬。蟋蟀輕視偶然碰到的隱避處，牠慎重的選擇住宅，要排水優良，有溫和的陽光。牠不利用既成的洞穴，牠的別墅一點點都是自己掘的，從大廳直至臥室。

一

1. 家門前，有甚麼？（小河）
2. 你常常到河邊做甚麼？（釣魚）
3. 小山在那裏？（家後面）
4. 你常常到山上做甚麼？（遊玩）
5. 甚麼在河裏？（魚）
6. 你常常到甚麼地方？（河邊及山上）

二

1. 回家見了誰？（爸媽）
2. 見到爸媽時，你說甚麼？（我回來了）
3 吃過飯後，你做甚麼？（功課）
4. 今天的功課，應該怎樣做？（今天就做好）
5. 有空時，你做甚麼？（家務）
6. 誰在玩，（弟弟和妹妹）

三

1 文中的地方是甚麼？（遊樂場）

2. 遊樂場裏，最多的是甚麼？（玩具）

3 弟弟玩甚麼？（木馬）

4. 哥哥玩甚麼？（飛機）

5 火車經過那裏？（山洞）

6. 小船在甚麼地方來來去去？（水面上）

四

1. 文裏的動物是甚麼？（老鼠）

2. 牠為甚麼感到高興？（沒有貓聲）

3 牠到那裏走？（廚房）

4. 牠找到甚麼？（找到鬼肉）

5. 牠找到肉後，想怎樣？（把肉偷走）

6. 牠走的時候發生了甚麼？（被困）

三

1. 文裏的動物是甚麼？（花鹿）
2. 牠們在那裏生活？（山林）
3 早晨牠們在樹林外做甚麼？（呼吸空氣）
4. 大鹿跑在山坡上做甚麼？（找食物）
5. 小鹿跑到最高的地方做甚麼？（看海景）
6. 他們生活過得怎樣？（快樂）

六

1. 黃道周甚麼時候進小學讀書？（五歲）
2. 誰講歷史故事給他聽？（父親）
3 歷史故事對黃道周有什麼用？（分好壞）
5. 他最有興趣的是什麼？（讀書）
6. 他是什麼人？（明朝的大學問家）

七

1. 天后娘娘是在那裏生長？（漁村）
2. 她學了什麼？（天氣和醫病）
3. 村民多以什麼維生？（捕魚）
4. 天氣對村民有什麼影響，（定捕魚日及大風浪）
5. 聽到天氣預告，村民得到什麼益處？（平安）
6. 村民有病，天后娘娘就做什麼？（摘藥醫病）

八

1. 文中主角的名字叫什麼？（秀娟）
2. 收音機播放什麼節目？（恐怖故事）
3. 聽後秀娟覺得怎樣？（心裡砰砰跳）
4. 秀娟的媽媽說甚麼？（夜了，快睡）
5. 然後她做什麼？（蓋被，熄燈）
6. 秀娟後來怎樣？（不能入睡）

九

1. 誰得到哥白尼的恩惠？（貧苦病人）

2. 為何原因？（不收費）

3. 他是用什麼方法治病？（科學化）

4. 他是否一個牧師？（是）

5. 牧師用何種方法治病？（祈禱）

6. 哥白尼有空時會什麼？（研究天文學）

十

1. 文中用什麼字來形容象？（最文靜）

2. 什麼時候象會憤怒？（受到侵犯）

3 牠的視覺怎樣？（遲鈍）

4. 聽覺怎樣？（敏銳）

5. 什麼食物對象是重要的？（樹葉和枝）

6. 小象出世時間是何時？（三月至五月）

十一

1. 文中講的是什麼地方？（桂林）

2. 獨特的風格是指什麼？（山水）

3 文中用什麼來比喻山的顏色，（寶塔和玉筍）

4. 文中光滑是指什麼？（岩壁）

5 為什麼山上岩壁光滑，
沒有泥土，只有亂草樹）

6. 傲然獨立，何解？

十二

1. 文中主角是誰？（蜘蛛）

2. 文中它的行業是什麼？（建築家）

3 對偶然碰到的隱避處，它的態度怎樣？（輕視）

4 他用什麼態度選擇住它？（慎重）

5. 選擇住它的條件是什麼？（排水優，陽光）

6. 他會怎樣對自己的別墅，（勤勞及小心地自己振）

APPENDIX C

STIMULI FOR MATCHING AND VOCALIZATION TASKS

Appendix C: Stimuli for Matching Tasks

A) High Frequency Characters

看 日 多 好 可 說 地 時 就 到 上 十 在 了 的
看 冷 東 本 經 說 地 有 各 到 中 十 能 了 性

民 麼 下 也 都 用 五 四 學 個 三 二 他 有 一
民 同 法 也 事 市 五 明 學 個 三 二 他 有 做

A) High Frequency Characters

出 成 子 作 去 第 年 會 要 和 這 來 人 國 是
出 成 子 作 最 對 年 會 要 山 沒 海 人 國 高

着 你 很 後 裏 小 家 生 天 以 [illegible] 們 大 不 我
開 師 等 如 沒 小 南 生 天 以 中 所 大 校 之

B) Low Frequency Characters

暢	戯	枚	擁	弓	乙	占	楠	枇	乞	悌	几	刁	兪	囚
粉	妨	枚	擁	弓	或	占	楠	枇	乞	悌	几	松	兪	旺

欠	卜	宅	岷	咳	互	池	巫	冬	未	茄	乏	吐	症	企
池	卜	宅	暗	宜	示	波	認	鞋	硫	茄	朵	吐	沙	伐

B) Low Frequency Characters

踈 滾 干 邮 刷 幻 浴 吊 哠 伕 丸 扛 尹 禾 夊

粒 液 吟 郵 刷 奶 裕 吊 得 伕 空 杷 |色 姓 夊

伏 巷 秒 兼 偏 孔 胎 疋 佔 亡 汁 召 丁 坒 尤

五 巷 秒 兼 咱 厚 胎 疋 府 亡 计 召 丁 坒 咭

C) High Frequency Words

先生 重要 不過 時間 方法 因此 地方 對於 今天 已經 社會 可以 世界 自己 問題 所以 方面 國家 生活 知道 家庭

那裏 而且 這些 時間 方法 計劃 地方 覺得 今天 已經 社會 一定 世界 多少 問題 所以 方面 先生 生活 知道 家庭

表示 學生 大家 雖然 開始 可能 日本 但是 必須 政府 工作 這樣 他們 如果 因爲 我們 從此 現在 美國 時候 那樣

因此 學生 大家 雖然 開始 可能 其他 但是 必須 精神 工作 這樣 他們 如果 主要 我們 孩子 東西 文化 表示 那樣

C) High Frequency Words

文化 東西 孩子 主要 精神 其他 參加 那裏 情形 多少 運動 環境 一定 覺得 計劃 這些 一樣 而且

不過 重要 時候 美國 從此 國家 參加 但是 可能 情形 運動 環境 先生 家庭 因爲 可以 一樣 對於

D) Low Frequency Words

要角 完美 波動 跳舞 飲用 知音 眼前 美意 紅色 忘掉 道義 花生 富強 石頭 身形 用具 電動 老弟 童年 樣品 汽水

身形 完美 波動 牙科 飲用 知音 眼前 美意 陳明 忘掉 道義 流水 角度 石頭 體重 空地 電動 兵力 整修 樣品 要角

角度 應答 睡眠 倒數 令兄 身上 食品 毛巾 花朵 魚業 牛皮 拖鞋 釣魚 遠東 機智 黑板 白熱 便士 酒樓 減小 限度

白熱 用具 老弟 童年 令兄 身上 食品 毛巾 花朵 汽水 圓滿 回去 平分 遠東 機智 黑板 耕種 便士 酒樓 減小 限度

D) Low Frequency Words

同行 圓滿 囘去 平分 刀片 耕種 牙科 陳明 流水 體重 落後 空地 兵力 耳目 出見 月份 軍士 整修

同行 魚業 倒數 睡眠 刀片 應答 牛皮 釣魚 拖鞋 跳舞 落後 紅色 花生 耳目 出見 月份 軍士 富強

E) High Frequency Characters for Vocalization Tasks

上
五
這
中
到
生
的
地
在
國
有
一
來
學
四
時
年
就
們
和
了
大
個
以
我
要
二
人
天
是
三
不
十
他
台